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## INDUSTRIAL FUNDAMENTALS

Summary of an Inquiry on "Economic Attitudes in Industry" by a Committee of the College of Engineering of the Ohio State University

That in the minds of many industrial leaders the conviction has arisen that industry does not exist for profit making merely and that industrial executives must learn to appreciate the social bearings of their work—these are perhaps the two main findings of an inquiry concerning "Economic Attitudes in Industry" just published by the Engineering Experiment Station of the Ohio State University.* The inquiry, however, goes into much further detail. Granted that executives must concern themselves with the social problems engendered by industry—what is the attitude of leading industrialists on some of these problems today?

We are asking colleges to produce socially minded engineers. Just at present our industrial system is, however, working very imperfectly. What would happen if these socially awakened young men should come to the conclusion that its very fundamentals are wrong and that the system must be made over root and branch. Manifestly, such young reformers might find a cold reception in industry—if they found any reception at all.

It is therefore well to ascertain what leading executives think about some such matters, technological unemployment, nationalization of industry, increasing consumers' buying power, old age pensions, etc., and what they propose to do about these things. We can then teach our engineering students industrial fundamentals with some regard for the attitudes found in industry on these matters to-day.

A few hundred men of standing and prominence in industry, mostly presidents and board chairmen of the nation's largest concerns, were asked questions of this nature, and some forty leading economists were asked the same questions, so as to see how business attitudes check with presumably somewhat more disinterested attitudes of academic experts. Over a hundred industrial leaders answered in some form or other and the answers of 97 proved capable of tabulation and analysis. Thirty-three economists answered, also.

* "Economic Attitudes in Industry," by F. C. Caldwell, C. A. Norman, and John Younger. Engineering Experiment Station, Circular No. 26, Ohio State University, Columbus, Ohio. Summary by C. A. Norman, Chairman of the Committee.

The questions and findings in detail are given in the original pamphlet, which may be obtained free of charge by application to the Ohio State University Engineering Experiment Station at Columbus, Ohio. Only brief indications of these findings can be given here.

The great majority of industrial leaders admit that industry is in a bad way just now; that it produces technological unemployment and other unemployment, and that it is in need of stabilization and rationalization. However, when one asks them how to stabilize and how to nationalize, there is great disagreement.

Thirty-two out of 74 answering this question believed that increase in productive efficiency would in itself gradually eliminate technological unemployment. Twenty-nine unconditionally and seven with some conditions thought that working hours should be shortened without reduction in weekly earnings and only 19 declared themselves definitely against this idea. A majority of the economists in addition took the stand that wages—at least real wages—should be continuously increased as technology advances; but the majority of industrial leaders refused to commit themselves to this.

There has been such an outcry against "the dole," *i.e.*, unemployment insurance, that it was surprising to find a minority of twenty-one industrial leaders unreservedly in favor of it, and fifteen more in favor of it with certain reservations. However, as is well known, an important fraction of the electric industry, the National Electrical Manufacturers' Association, has come out in favor of this scheme as contained in the so-called Swope plan.

It used to be said that "the poor will always be with us," but this is a strange thing to say in a nation where every worker has about a hundred mechanical slaves—5 hp.—at his disposal. President Hoover has often spoken about the abolishment of poverty and Henry Ford has talked about wages of $27.00 a day by 1950. It is comforting to see that a majority of business leaders (51 out of 80) answering this question believe that industry should be able to supply all citizens a standard of living at least sufficient for health and decency.

As to what this means in dollars and cents, there is a great deal of divergence of opinion. The estimates vary all the way from $1,000 to $3,000 per year. The average guess, however, agrees quite well with rather careful estimates made by the United States Department of Labor during the war; by Professor Ogburn and others. These estimates cluster around $2,000.

It is clear, however, that much larger incomes are needed to acquire all those things which modern invention could bestow on the people—automobiles, radios, good homes, etc. The estimates

just referred to contain no allowances for such things. The government estimate sets aside a bare $20 a year for recreations of all kinds. What incomes would be necessary if people are really to share in all the new conveniences which technological progress provides?

The estimate by Professor Peixotto of what it takes a university teacher to maintain proper contacts and reasonable modern conveniences is $7,000 a year. Probably a man in ordinary commercial pursuits expects no less.

Is there any possibility so to coördinate industry that it could provide incomes like this for people generally, or what would be an absolute maximum that could be secured with present facilities?

In answering these questions one of the economists takes an estimated national income of 80 billions of dollars—which has been exceeded in the prosperous years from 1925 on—and divides it among 24 million families, thus securing $3,300 for each. Moreover, it has been reasonably estimated that industry could produce 40 per cent. more goods than it has been producing, even in a prosperous year. Adding this, we get an average income of $4,620 as possible per family now. More would come with improved efficiency. Even with quite liberal allowances for industrial reserves, profits and what not, it would appear perfectly possible to grant a rather high standard of comfort to all the people.

This conclusion is lifted out of the realm of mere theory by our experience during the war. With four million workers drafted into the army and with seven million more engaged in the manufacture of war materials, that is, with more than 25 per cent. of all gainfully employed people withdrawn from their regular pursuits, the remaining 75 per cent. supplied the masses of the population with a standard of affluence they have hardly enjoyed either before or since. This, however, was brought about by a deliberate planning of the nation's industrial activities with just one end in view: the supplying of the nation's needs.

Asked whether they felt that also in peace time the industries should be so systematized that they would at all times supply the needs of the people, 65 business leaders answered "yes" without qualifications, five answered "yes" with some qualifications, and only seven answered "no" categorically.

The difficulty only comes in the question of means. The medley of answers to this question was such that no attempt even to marshal them in an orderly fashion seemed possible.

There is only one thing about which industrial leaders are fairly united. The vast majority—75 against four—do not believe in

government ownership and operation of industries, except perhaps when the security of the nation is at stake.

The economists presented a very different attitude on this question—12 were for government ownership without qualification, ten were for it with qualifications, such as "under some circumstances," etc.; only one was categorically against it, two were against it "at present."

During the war the industries submitted to a vast amount of control and regulations. To quote the pamphlet "With its Food Administration, its Fuel Administration, its Railway Administration and its War Industries Board the nation toward the end of the war was fast becoming one great methodically operated productive enterprise."

After the war, however, this organization was speedily broken down. One might wonder whether the crisis of 1921–22 and again the present terrible depression could not have been avoided if the nation's economic life had continued to be directed by some responsible governmental agencies.

Evidently, however, the majority of business leaders do not take kindly to this sort of control. Asked whether they thought that industries can be coördinated on a national scale entirely through voluntary efforts of individual enterprises, 51 business leaders answered categorically that they did, and 12 more took the same attitude with some reservations. However, thirteen were quite sure that such spontaneous coördination would be impossible and some others are rather doubtful on the subject.

Among the economists, 16 out of 27 answering the question declared voluntary coördination impossible; only three declared it definitely as their belief that it was possible, while eight more deemed it possible with certain reservations.

It should be noted here that in the one industry, the electrical one, where serious thought has been given to this matter, the plan of coördination adopted—that of President Swope of the General Electric Company—contemplates the necessity of government compulsion to force recalcitrant concerns into the trade organizations through which coördination is to be effected.

While the majority of industrial leaders are rather against government regulation as a means of industrial rationalization, they come out rather surprisingly in favor of some things which only radical and labor unions until recently used to clamor for. These are a shorter working period and old age pensions. The great majority of those hazarding an estimate think that an eight-hour day and a five-day week is the standard toward which industry is tending. Forty-four took this attitude. Only eight came out for

an eight-hour day and a 5½ day week, and only four for a six-hour day and a five-day week. All other combinations received but scattering votes.

As to the old-age pensions, 69 industrial leaders were definitely for them and six more were for them with certain reservations. Only 17 were definitely against them.

The preponderating sentiment was that the industries should provide these pensions without government compulsion, but the manager of a great electrical concern insisted that old-age pensions should be made compulsory by law, so that less public-spirited concerns should not be able to take an unfair competitive advantage of the more public spirited ones. The majority of economists also took this attitude. Only minorities favored pensions supported by taxation, although of course unless pensions are made a public burden, individual concerns will hesitate to hire a man approaching pension age.

We can here but touch on several other things in the pamphlet. It was, however, very refreshing to note that a great deal of open-mindedness appears on many questions on which the business mind has tended to be quite closed before. Thus the majority admit frankly that labor unions can be brought to coöperate in improving efficiency—as of course has been demonstrated in the shops of the Baltimore & Ohio Railroad, etc. They also admit, by a two to one majority, that high pressure salesmanship has been overdone.

The important thing for engineering educators to realize is, however, the almost universal demand for more cultural training and a wider social outlook among industrial executives. No less than eighty-one industrial leaders expressed themselves without qualifications in this direction; five more answered "not needed but helpful" and only four answered "no."

Asked for definite suggestions as to what subjects should be taught to attain this end, there was a surprising mass of suggestions. The greatest number of votes of business leaders, however, clustered around the following subjects, with numbers as indicated in brackets: Accounting (10); business administration (16); economics (42); English (23); history (25); psychology (18); public speaking (16); social science and social service (10).

Considering the fact that in most engineering schools some two thirds of the graduates gravitate into executive and commercial rather than into strictly technical pursuits, it would seem that these subjects should be given fully as serious attention as the fundamental technical and scientific subjects.

It may be said that in recognition of this fact the faculty of the College of Engineering at the Ohio State University has already

voted to devote three hours a week to these subjects throughout the junior and senior years.

ACKNOWLEDGMENT

The Committee wishes to take this opportunity to express its indebtedness to Dean E. A. Hitchcock, of the College of Engineering of the Ohio State University, for authorizing and in every way furthering its study, and to Dean Hitchcock and Mr. J. M. Weed, assistant director of the Engineering Experiment Station, for arranging for the publication of the study as an Engineering Experiment Station Circular.

# A STUDY OF ELEVEN REPRESENTATIVE AMERICAN ELECTRICAL ENGINEERING COURSES *

By JAMES C. CLARK,

*Professor of Electrical Engineering, University of Arizona*

In recent times, two very valuable large-scale studies of engineering education have been made. The first, that of Dr. C. R. Mann, sponsored by four national engineering societies and supported by the Carnegie Foundation for the Advancement of Teaching, was reported in 1918 as Bulletin Number 11 of the Foundation. Again, beginning in 1923, this Society conducted its most exhaustive investigation of engineering education under the able leadership of Dr. W. E. Wickenden and Prof. H. P. Hammond. From time to time, parts of the findings and reports made under this investigation were published in our Society's JOURNAL OF ENGINEERING EDUCATION. Pamphlet reprints were also issued, and in 1930, these papers were published in one large volume entitled "Report on the Investigation of Engineering Education, 1923-1929." Both these studies have proven tremendously valuable to progressive teachers who turn to their data and findings for inspiration and guidance.

The present paper is prepared at the instance of Committee Number 17, on Electrical Engineering. Its aim is to present the results of a modest study, made by the writer, of the current undergraduate curricula in electrical engineering of eleven representative institutions in America. In two ways, this study constitutes a sort of sampling of American curricula; *i.e.*, only a very limited number of curricula is examined, and, in these few, only a rather small number of subjects is studied. Both these limitations have seemed necessary because of consideration of time and space.

It is thought that evidences of substantial progress, or lack of it, may be found by comparing the condition of even the limited number of courses now examined with the findings and recommendations of the more thorough-going reports that have been mentioned. The responsibility for making selections of curricula and for the treatment of the whole subject rests entirely with the writer. The choice of schools was governed, primarily, by the thought that it is desirable to include courses from institutions varying in character and environment, and, secondarily, by the accessibility of informa-

* Presented at the 39th Annual Meeting, S. P. E. E., June 17–19, 1931.

tion. Please note that no claim is made that the courses chosen are the *best* ones, nor even that they are necessarily the most interesting eleven that might have been selected.

Under such curriculum subjects as are here discussed the method of presenting the material is, whenever feasible, first, to quote as briefly as possible, any relevant matter from the Mann Report and from the Wickenden Report; second, to present available data on the curriculum; third, to discuss the topic in the light of these quotations and facts.

There are also presented brief accounts of more or less novel features of certain electrical engineering curricula that seem to challenge attention because of their experimental nature, or because they are apparently the result of a conviction of the great value of certain subjects or methods, even though they may be almost unique.

Although the paper considers only electrical engineering courses, a number of things in it may be of some interest to instructors in any branch of engineering.

## Courses Included

Alphabetically listed, the courses that have been studied are:

Arizona, University of
Armour Institute of Technology
Case School of Applied Science
Drexel Institute
Iowa State College
Massachusetts Institute of Technology
Pennsylvania State College
Pennsylvania, University of
Purdue University
Washington, University of
Wisconsin, University of

Of these schools, four are eastern institutions, five are midwestern, and two are western.

## Matters Examined

The specific subjects within the various curricula that seem to the writer to warrant special attention are: orientation (of underclassmen), English, shop work, electrical machine design, engineering economics, and undergraduate thesis. Other important matters that draw attention are: special treatments of individuals (such as the functional plan and honors courses), restrictions in choice of electives, exploratory courses, and special features of certain curricula. These various topics are taken up in order.

## Orientation Courses

### *Mann Report*

Page 58: "Instructors who are close to freshmen and sophomores tell how bewildered and discouraged the under classmen often are. . . ." "Several of the schools visited have found that the introduction of 'orientation' courses . . . are effective means of increasing the interest and strengthening the morale of the freshmen."

Page 88: ". . . essential requirement of all engineering curricula is adequate provision in the first two years for 'orientation' . . . and practical experiences that make the boy feel that he has . . . entered upon a professional career."

### *Wickenden Report*

Page 183: "Measures to . . . guide the student of engineering should not cease with his admission to college." "Of late years, we are beginning to . . . appreciate our responsibility for assisting the young man to . . . choose his course in engineering intelligently."

Page 184: "In choosing a particular engineering course the student's personal preference, if intelligently arrived at, should be the chief factor. The purpose should be to enable him to form such preferences on a valid basis."

Page 187: ". . . many indications of the realization of the existence of the problem (of choice of course) and of the increased understanding of it, and the many earnest efforts which are being made to solve it are distinctly encouraging."

Page 211: (Speaking of a primary cause of high elimination.) "The absence of that vocational stimulus in the daily work of many students which comes to those who have been able to base their choice of a career upon adequate information about the profession they are entering."

Page 212: "The matter of vocational information . . . demands more attention than has hitherto been given it by engineering educators" ". . . investigations prove conclusively that a large proportion of our student body has been admitted to and eliminated from engineering colleges without gaining any simple and useful concept of what engineering is."

### *Status of Orientation Courses*

Six of the curricula studied contain orientation courses as follows:

*Arizona:* Freshmen take occasional lectures through one semester.

*Iowa State College:* A series of technical lectures is given in each quarter of the freshman year.

*Pennsylvania State College:* A laboratory course for the freshman electrical engineer enables him to determine for himself as soon as possible after he enters college "whether he chose wisely when he chose electrical engineering as a career."

*Purdue University:* All engineering freshmen are required to take orientation courses. Three hours per week are given through two semesters.

*Washington, University of:* An engineering problems course is given throughout the year; three units credit each semester.

*Wisconsin:* All freshmen are required "to attend a course of lectures."

*Comment*

Granting the rather dubious assumptions that the preparation of entering freshmen is always adequate and that those who choose engineering are making no serious error of judgment, experience indicates that, nevertheless, some method is needed for guiding these beginners into the branch of engineering for which they are best fitted.

It is seen that some effort, though probably not enough, is being made to acquaint freshmen with the nature of the various branches of engineering. The effort seems to be confined largely to orientation lectures, but it also seems quite possible that the work of a laboratory, or a problem course, may provide a more tangible basis for the student's selection of the proper division of engineering.

## English

*Mann Report*

Page 41: "With regard to instruction in English, the engineering schools may be divided into two approximately equal groups, the one composed of those schools that maintain the current standard college course, and the other composed of those that are trying to discover a type of work better suited to engineers."

Page 42: "Doubtless because the professional engineers have been so frank in their demand for better training in English, about half the engineering schools are experimenting with their methods of teaching this subject. These experiments are so varied in plan and execution that it is not possible to classify them."

Note: Dr. Mann describes in appropriate sections of his report the success of the "striking experiment . . . now being made by Professor Frank Aydelotte . . . at Massachusetts Institute of Technology."

### *Wickenden Report*

Page 148: "Unless the levels of preparatory education are exceptional, we deem it essential to include instruction in English . . . in all engineering curricula. Furthermore, we favor an unremitting insistence on clearness and accuracy of expression in all work, written or spoken, performed by engineering students, and think it proper to deny graduation to students whose daily work does not bespeak a relatively high standard of literacy."

### *Status of English Courses*

*Arizona:* Each of the freshman semesters contains a three-unit course in composition. "Emphasis is on exposition."

*Armour Institute:* Two-unit course in "Rhetoric and Composition" each semester of the freshman year. One-unit course in second semester or sophomore year in "Advanced Composition." There are also several courses in "Literature."

*Case School:* Freshman year; three-unit course in "The Essay" in the first semester, three-unit course in "Argumentation and Debating" in the second semester. Sophomore year; three-unit course in "Technical Exposition" in first semester. Junior year; three-unit course in "Types of Literature" in second semester ("some written discussion"). Senior year; two-unit course in "Business Composition" in second semester.

*Drexel Institute:* Each of the first three quarters of the course contains a three-unit course in "Composition and Literature."

*Iowa State College:* Freshman year; a three-unit course in each quarter of the year. Fall Quarter, "Composition"; winter quarter, "Exposition"; spring quarter, "Narrative and Description." Senior year; three-unit course in fall quarter called "Advanced Composition."

*Massachusetts Institute:* Freshman year; two units each semester in "English and History."

*Pennsylvania State College:* Freshman year; three-unit course in "Composition" in first semester, three-unit course in "Exposition" in second semester. Sophomore year: two-unit course in "Argumentation" in first semester, two-unit course in either "Technical Writing" or in "English Literature" in second semester.

*Pennsylvania, University of:* Freshman year; two-unit course in "English Composition" in each semester. Sophomore year; two-unit course in "English Composition" in second semester.

*Purdue University:* Freshman year; three-unit course in "English Composition" in first semester, three-unit course in either "The English Essay" or "The English Drama" in the second

semester. Senior year; three-unit course in either "English" or "Option" in second semester.

*Washington, University of:* Freshman year contains no English courses. Sophomore year; three-unit course "English 100" "an intensive course in expository writing," in the third quarter. Junior year; three-unit course "English 102," "directed reading and writing" in first quarter.

*Wisconsin:* Freshman year; three-unit course in each semester in "Freshman Composition."

*Comment*

From this array of data on English for electrical engineers in the various institutions, there might seem to be adequate emphasis placed upon this subject. There remain some important questions, however, in regard to: (1) the attitude of under classmen toward this subject; (2) the relative stress placed upon composition—especially *exposition* and upon literature studies. These questions are never clearly answered by catalogue descriptions. Numerous engineering instructors believe that English courses should stress expository writing to the exclusion of nearly all other sorts, and also that time spent by underclassmen on English literature is largely wasted.

## Shop Work

*Mann Report*

Page 75: "In American technical schools shopword still occupies an anomalous position . . . there is no agreement as to the purposes and methods of shopwork." "Nearly every school has a shop philosophy and a well-organized shop method of its own."

Page 78: "Certain it is that in the great majority of schools there is no direct connection between shopwork and industrial production. Under the present changed conditions, the question is now being seriously debated whether the shop courses in the engineering colleges ought to be altogether abolished."

Page 90: ". . . some schools are seriously considering giving up shop work, since it is not at all clear why skill in the handling of tools is essential to every engineer."

Page 98: "This (participation in industrial work) is suggested as a substitute for most of the current shop practice, such elements as should be retained in school being included in the engineering laboratory work."

*Wickenden Report*

Page 34: "After a sudden increase in time (in engineering curricula) devoted to shop work in the early years, the amount of

this work has gradually decreased, except in mechanical engineering."

Page 239: "It will be noted that (engineering graduates, in rating effectiveness of college work) . . . place training in craftsmanship last."

Page 381: "Shop is held to be of moderate importance by all" (of a group of Eta Kappa Nu members whose opinions of college courses were gathered).

Page 538: (Among trends in engineering curricula) "the general technical groups give evidence of the declining position of shop work . . ." ". . . the emphasis given to manual arts has been steadily declining, with a corresponding gain in emphasis on the analytical side of engineering."

Page 545: "By 1885 shop work had attained its maximum position in engineering curricula. . . ."

Page 552: (Since 1870) "the growth of time given to technical engineering subjects has been primarily at the expense of graphics and shopwork. . . ."

Page 670: "In response to a specific question, a slight majority (of professional electrical engineers) consider it desirable to substitute a definite amount and type of shop experience gained during vacations for systematic shop instruction in college."

### *The Curricula*

*Arizona:* Sophomore year; pattern, two units in first semester. Forge, two units in second semester.

*Armour Institute:* Freshman year; forge, one unit in first semester and foundry, one unit in first semester. Sophomore year; pattern, one unit first semester and machine, one unit second semester. Junior year; machine, one unit first semester.

*Case School:* Sophomore year; machine, one unit course each semester.

*Drexel Institute:* Third quarter, one and a half quarter-unit course machine shop. Fourth quarter, one and a half quarter-unit course in advanced machine shop. Sixth quarter, one and a half quarter-unit course in heat treatment and welding.

*Iowa State College:* Freshman year; forge, two quarter-unit course in first quarter. Foundry, two unit course in second quarter. Machine, two unit course in third quarter.

*Massachusetts Institute:* Sophomore year; foundry, one unit and machine tool laboratory, one unit in first semester. Sophomore year; machine tool laboratory, two unit course in second semester.

*Pennsylvania State College:* Freshman year; wood shop, one unit first semester, and foundry, one unit second semester. Sophomore year; pattern, one unit first semester and machine one unit second semester.

*Purdue University:* Freshman year; foundry (or pattern) one unit first semester, pattern (or foundry) one unit second semester. Sophomore year; forge (or machine) one unit first semester, machine (or forge) one unit second semester.

*Washington, University of:* Sophomore year; foundry, one unit first quarter, forge, one unit second quarter, machine, one unit third quarter.

*Wisconsin, University of:* Freshman year; pattern, foundry, forge, and welding, two units in first *or* second semester. Sophomore year; machine, two units second semester.

### *Comment*

For a dean or a professor of electrical engineering to have a clear-cut notion of the subjects to be attained by shop work courses or of the relative value of such courses seems to be exceptional. At all events, it is clear that they are, in many places, being crowded out to make room for courses having more definitely understood objectives.

## Design on Electrical Machines

### *Mann Report*

### *Wickenden Report*

Nothing appears in either of these studies that may be construed as a recommendation in relation to this subject.

### *The Curricula*

*Arizona:* Required. Two units in each semester of the senior year.

*Armour Institute:* None given, but "Central Station Design" is carried throughout the senior year.

*Drexel Institute:* Required. One and a half quarter-units total in "fundamentals in design of various types." "Actual design of a direct current dynamo."

*Massachusetts Institute:* An elective in the fourth year.

*Pennsylvania State College:* Required. One unit in each semester of the last two years.

*Purdue: Required.* Junior year; one unit second semester. Senior year, three units first semester.

*Washington, University of:* Required, three units last quarter of junior year. Senior elective, a four-unit course is offered in alternating current design.

*Wisconsin:* As elective, a three-unit course is available in second semester, senior year.

*Comment*

During the last ten or fifteen years, electrical machine design has been losing ground in electrical engineering curricula. In the writer's opinion, this is a most regrettable phase of change. The trite phrase used by those who defend its omission is, "We can't make designers in college anyway." But probably it was never contended by any honest instructor that he *could*. It should not be forgotten that design problems satisfy, approximately, that desired third element in engineering training, construction planning the other two elements being theoretical foundation and experimental verification. The majority of curricula contain none too many opportunities for the exercise of the imagination, and the fostering of creative ability. For these purposes design lends itself admirably.

## Engineering Economics

*Mann Report*

Page 43: (In engineering instruction) "some attention—frequently very little—is given to the practical problems of labor, organization, values, and costs."

Page 63: "There has always been and still is a strong aversion on the part of colleges to placing emphasis on the material and financial aspects of the engineer's work. Yet it is a burning question whether the commercial bearings of each subject cannot be introduced into each course in such a way as to increase enormously its use and its vitality without in the least impairing its inherent scientific value. The enrichment of the content of courses by judicious appeal to practice and costs is a problem that offers rich opportunities for further experiment."

Page 90: "The real purpose for which engineering schools were established is to increase industrial production, because the ultimate aim of engineering is more intelligent production. But every production project requires the coördination and adjustment of three factors, namely, scientific theory, mechanical practice, and cost. . . . engineering education is likely to be more effective in proportion as it fosters the development of skill in determining the most expedient adjustments among theory and practice and costs."

Page 93: ". . . technical work is more impelling, and is, therefore, more fully mastered, when it includes the consideration of values and costs" ". . . the ultimate control of all engineering projects, as of all activities, is vested in some man's decision that the game is really worth while; and this control is likely to be more salutary, the more completely the man who decides

comprehends the full import of the values and costs involved."

Page 99: "A . . . departure from current school practice is made in the recommendation to emphasize the problems of values and costs. This topic has obtained scant recognition in higher education for fear of contaminating university ideals with those of the market place." ". . . it may be made the most potent means of expressing the highest type of university spirit."

Page 111: ". . . the determination of costs is relatively easy so far as men and materials is concerned; but the overhead, because it includes the cost of maintaining the organization, is a matter of great difficulty."

Page 112: ". . . the schools have already discovered that students learn best when they are inspired by the conviction that the work is really worth while. One of the most effective ways of making work seem worth while is by constantly relating it to the consideration of the whole range of values involved and all the costs. Every decision in daily life is an answer to the question whether the value is worth the cost."

*Wickenden Report*

Pages 11, 12: "It is not surprising . . . that the functions of the engineer have become more complex and are interrelated with many activities of modern Life. Engineering education must deliberately provide the way for the solution of problems in the field of social utility as well as the application of scientific principles to specific technical problems. The strictly technical professional activity is comprised in engineering but it is not a definition of it. What engineering education must have is a guiding philosophy based on a clearer visualization of the place of engineering in modern life."

Page 44: ". . . evidence gathered . . . led to the conclusion that instruction in the principles of economics and their application to problems of engineering practice were not in as satisfactory condition as other indivisions of the curriculum. Much evidence points to the conclusion that neither the type nor the extent of the economic training of engineering is commensurate with the vital importance of the economic phases of engineering work."

Page 45: "Asked to state their opinions as to the more important omissions from their college courses, over one-half of all replies from younger graduates (classes of 1922, 1923, and 1924) cited economic, business, and commercial subjects as the most serious ones."

Page 35. "General economics and engineering economics are shown as foundation subjects bearing somewhat the same relationship to the entire group of professional subjects as do pure and

applied mechanics. This relationship . . . is one of primary importance, though at present it is probably more a fond hope than a reality."

Page 46: "There seems to be rather general agreement that more than the present emphasis on economics and its application in engineering should be given; that sufficient time is now devoted to the subject of general economics as taught by the Departments of Economics and that it would be desirable to provide for specific instruction in engineering economics, and to devote greater attention and emphasis to economic phases of engineering problems in the engineering subjects themselves."

Page 79: "The plan of instruction might well provide . . . a larger emphasis on the economic basis of engineering. . . ." "In an ideal conception of the curriculum, economics would be ranked with the physical sciences as one of the foundations of engineering. The present formal treatment of the subject does not seem to be based on such a conception, but rather that of a collateral subject of primarily cultural value. As long as this conception prevails, the provision of time for work in formal economics seems adequate, in most cases. If the treatment of the subject could be made to articulate closely with the interests and problems of engineering, a more generous time allotment would be warranted."

Greater emphasis on the economic aspects of engineering subjects proper seems clearly to be feasible and desirable." ". . . the most immediate step to be taken to qualify the engineer for larger responsibility in industry and public affairs is to increase his competency as a working economist and to win a wider recognition of this aspect of his work."

Page 90: (As a distinct objective) "The second is the capacity to deal with specific economic problems and social situations arising within the realm of engineering; it is essentially technical and is a responsibility of engineering educators."

"Tangible progress . . . depends equally on steps to be taken by social scientists to make their work more significant to engineers and by engineering teachers to develop more adequate methods of dealing with the technique of economy, both financial and human."

Page 91: "Considerations of social and financial economy deserve a larger place in all distinctly engineering subjects. More specific attention should be given to the criteria by which the relative economy of different procedures may be judged, and to the technique by which economy may be analysed."

Page 73: "In general, we do not favor a distinct curriculum to give special stress to the economic and managerial aspects of engineering, which we regard as common to all the major technical divisions."

### *The Curricula*

*Arizona:* Elective. Available as an elective two-unit course in second semester, senior year.

*Armour Institute:* Required. One and one-third units, first semester, senior year.

*Iowa State College:* Required. Three units, third quarter, junior year. Three units in Engineering Valuation, spring quarter senior year.

*Purdue:* Required. "Engineering Administration," three units in each semester of senior year.

*Wisconsin:* An elective in "Engineering Administration" may be taken by seniors, though apparently no definite course in engineering economics is available.

### *Comment*

Despite the widespread interest in problems in engineering economy, and the very real demand for emphasis upon this subject in curricula, instruction in the subject is so rarely given that it constitutes the exception rather than the rule. This is one of the most startling and deplorable conditions revealed by the present study.

## The Undergraduate Thesis

### *Mann Report*

Page 43: "Twenty-five years ago every senior was required to prepare a graduation thesis as an exercise in the application of all he had learned and a training in engineering methods of attacking real problems. At present only half of the schools require these of all graduates; in one-tenth the thesis is elective, in one-tenth the better students only are allowed the privilege of preparing one, and in the remaining three-tenths no thesis is required. Formerly the thesis was frequently the only opportunity given the student to exercise his originality and express his initiative in constructive work. At present engineering projects are being used more and more as problems and exercises in the regular class work of the last two years. In a few cases real engineering problems are freely used with freshmen and sophomores. These tendencies to encourage a spirit of investigation among the younger students and to give even freshmen opportunities for creative work are becoming more marked each year."

### *Wickenden Report*

No particular recommendation is made unless the suggestion contained on page 103, as follows, may be considered as related to theses:

"This result (securing greater student autonomy) may be sought through . . . a replacement of simplified exercises by problems and projects of substantially real magnitude and complexity. . . ."

*The Curricula*

*Case School:* A graduating thesis is required of all students.
*Massachusetts Institute:* Thesis is required.
*Purdue:* Thesis is required.
*Washington, University of:* Thesis is optional with electives.

*Comment*

It appears that the thesis for the bachelor's degree is required in decidedly few cases. In many of the older institutions, it has been abandoned. In many newer ones, it seems never to have been required. To inquire thoroughly into the arguments for and against the senior thesis would be a large undertaking lying beyond the scope of this paper, but one which the writer believes well worth while. Quite probably the arguments against it would be about as follows:

(1) It is difficult to find worth-while thesis subjects.
(2) The burden of furnishing special equipment is too great to be borne.
(3) The burden of administration of numerous theses is intolerable.
(4) The results in student training do not justify a place in the curriculum for the thesis.

Of these points, the writer believes that only the second and third may be tenable. Probably whether they are tenable depends respectively upon the existing ratios of equipment and size of staff to the size of the senior class. In answer to the first objection, it will always be found that ideas for valuable theses will come in large number to every instructor who maintains close contact with the industry. By no means must thesis subjects always be unique nor need they always be experimental. There are innumerable problems in industry that need for their solution the assistance of the colleges.

In analyzing the value of the thesis as an instrument for student training, the question may be reduced to a series of such questions as these about other subjects as compared with the thesis:

(1) Do they compel the student to become thoroughly familiar with the literature of some special field?
(2) Do they reveal the extent of the latent capacity of the student for research, and do they develop such latent capacity?
(3) Do they afford the same opportunity for complete mastery of some subject?

(4) Do they provide equally good channels for important expository writing?

(5) Do they acquaint the instructing staff as fully with the student's initiative, his industry, his intelligence, his thoroughness?

If the answer to each of these questions is an unqualified "yes" there seems to be no argument for the thesis.

The arguments against specialization in an undergraduate course are too well known to need repeating here. On the other hand, there is a growing sentiment that a student graduated with a bachelor's degree should know some one thing well; that he should approach a *mastery* of some phase of his field. This need not conflict with the essential desideratum that he should possess some real knowledge of his whole major branch of engineering. The educational arguments for such special mastery are obvious. If the point is well taken, is there any more effective medium for approaching such mastery than the senior thesis?

### Special Treatment of Individuals

One of the commonest criticisms of modern higher education and one of the most valid is that it is too machine-like; that quantity production seems to be its goal; that there seems to be a modicum of development of individuality. To this is added the observation that standardized treatment of human material tends to bring the specially gifted toward a "deal level of mediocrity"; also that the student of lesser gifts is not even lifted toward the mediocre average, but that—unless he is promptly "weeded out" in the early stages of his course—his slender talent finds no chance whatever for development.

The special treatment of individuals is obviously a most difficult thing to achieve. This is particularly true in the largest institutions where the major professor can have a personal acquaintance with but few, if any, of his seniors. The sectioning of large classes often results in entrusting the details of important matters to the mercies of a student assistant whose experience may be negligible, and whose progress in the subject is often but little beyond that of the students in his charge. Here is the place where the small college has a shining advantage. With a senior class of a dozen or fewer, it is possible for each student to be known thoroughly by his professors.

As a partial solution to this problem, students may be grouped into divisions which recognize, say: (*a*) differences in ability or "mental speed"; (*b*) differences in temperament. Experimentation under (*a*) is surprisingly rare. Among the institutions here studied, the Massachusetts Institute of Technology seems to be the

only one that is taking steps in this direction. Professor Timbie writes: "The plan (is used) of dividing the students up into at least three sections on the basis of their mental speed, using different methods of instruction for the different sections. All three sections are assigned the same daily lessons, the same problems, take the same quizzes and final examinations, but the class room work for the fast section consists of further application of the theory to other fields than those mentioned in the textbook. No classroom time is taken in drill on textbook material. In the slow section the classroom time is given up almost entirely to drill upon textbook material and problem solving. In the intermediate section a combination of these two procedures is used."

Closely related to the foregoing is the "Honors Plan" by which a number of the upper classmen are selected upon a basis of scholastic standing attained in the earlier parts of the program. Of the "Honors Group" at Massachusetts Institute," Professor Timbie writes:

"These men are selected at the end of their sophomore year upon the basis of their grades in the major subjects of their freshman and sophomore years. These men are given the privilege of not attending class room sessions and are encouraged to take this privilege. With the time thus gained they are supposed to do more intensive reading and study upon some part of the curriculum in which they are especially interested. They are not required to attend the class room sessions but take the final examinations, except at the end of their senior year when they take a comprehensive examination. Each department provides a special counselor for the men, who in weekly conferences goes over their studies and advises them concerning future work. Failure to maintain a high scholastic standing during any term causes a student to be dropped from the honors group."

At Drexel Institute, an "honors Course," E. E. 51, is open to "selected students."

The "Functional Plan", suggested by Professor Edward Bennett,* which aims at division by differences in temperament is not in effect, apparently, at any institution, unless we may call the provision of considerable latitude in professional electives in some schools a recognition of this principle and a step toward it. In the Wickenden Report, page 72, there are presented the arguments for and against both the proposed functional plan and the generally existing technical plan. The conclusion reached therein is, on the whole, rather against the functional plan, at least as a major

* "Engineering Courses for the Functional Rather than the Industrial Divisions of Engineering" by Edward Bennett; ENGINEERING EDUCATION, June, 1924.

scheme. As one of the strongest arguments against it. Dr. Wickenden alleges "the impracticability of detecting functional attitudes at an early stage of the program."

Even though many practical difficulties impede the progress of special treatment of students, some sorting must inevitably be done as a factor in their proper placement following graduation. Any method that secures correct data in the determination of individual abilities and temperaments seems well worth while. It is an astonishing fact that so little experimental work is being done toward that definite end.

## Restrictions in Choice of Electives

### *Wickenden Report*

(Subsidiary Report of Dr. Walton C. John, on "A Study of Engineering Curricula.")

Page 505: "Fifteen institutions of the seventy-eight specify non-engineering electives as a part of graduation requirements in electrical engineering."

### *The Curricula*

*Armour Institute:* Breadth of training is secured by specification of almost all courses, leaving the number of free electives at only two units in the second semester of the senior year.

*Case School:* Specification of nearly all courses. Three units of electives in second semester, senior year.

*Iowa State College:* The senior year contains three units of electives in each of the fall and winter quarters. There are seven elective units in the spring quarter. Of the ten units in the winter and spring quarters, not less than six must be non-technical.

*Wisconsin:* Professor Edward Bennett writes as follows:

"Shortly after the meeting of the Deans of the Midwest Engineering Colleges, at which a resolution was passed recommending the liberalization of the engineering courses, the department modified the course of study by requiring the students to elect non-professional engineering studies in a band extending from the end of the freshman to the senior year. Previous to this modification of the course, it had contained a number of free electives which were listed mainly in the senior year. While the advisers attempted to have the students use these electives to obtain work in the College of Letters and Science, it was the general experience that electives were devoted mainly to the obtaining of additional studies along electrical engineering lines. With the purpose of bringing to the attention of the students the possibilities of work in Letters and Science in conjunction with their engineering studies, the department relinquished some of the professional re-

quirements and made the requirement stated above that the student should start to elect non-professional studies in his sophomore year. We have now had eight years of experience with this experiment. We now have no difficulty in having the students elect non-professional work, and we feel that as a result of these non-professional studies our students make stronger citizens in their home communities."

*Comment*

The examination of electives show a tendency to restrict the inclination, frequently found, of upper classmen to elect only technical or professional subjects and to fight shy of those subjects designed to give them culture. The converse problem, that of inducing another type of man to elect sufficiently stiff courses seems not to have given faculties the same degree of concern, although it is the writer's conviction that it is a problem equally serious with the first. That it is advisable to guide the choice of practically all elective studies is borne out by the experience of many teachers.

A rough, and admittedly sketchy, division of students may be made into two groups; the serious, technically-minded men, and the more or less frivolously inclined. The first group tends toward too close concentration on technical and professional subjects to the exclusion of a very desirable knowledge of the group of social studies. If left to their own devices, such men will later be identified as the hewers of wood and the drawers of water. They have the brains for leadership but lack sufficient knowledge of human nature to qualify for it. They need wise counsel while at college to the end that they may develop into well-rounded men.

The second group is typified by the student who barely "gets by" in his technical subjects, and who flits like a butterfly from one "fruit course" to another. He knows humanity, yes, and often studies most assiduously the psychology of his instructor, hoping to pass the course without knowing much about the subject. Let the young, unsuspecting instructor beware of the "apple-polishing" tendencies of this second type of student. If he has capacity, he may be compelled by competent instructors to master his technical subjects. If so, he is a lucky man, and he may go far.

It will be seen that either of these types should benefit tremendously by being coerced into taking those very subjects that his personal tastes would lead him to avoid. That there is occasionally another type who really knows what he needs cannot be gainsaid. Every experienced teacher has seen such students but they are so rare as to be practically negligible in occurrence. It is too much to be expected that our youngsters will have the best, or even

good judgment, in the unpiloted shaping of their careers. In general, it is not a thing to be greatly deplored that our electrical engineering courses contain so small a percentage of free electives.

### Exploratory Courses

The tendency is growing in colleges to require all freshmen to take a number of exploratory courses, the avowed purpose of which is to make sure that all graduates shall be well-rounded men, acquainted with all the phases of human thought and endeavor; that no man shall leave college as a narrow specialist. This ideal is indeed a consummation devoutly to be hoped for. And how beautifully simple its attainment, if the exploratory course method only worked! Let those who would try it make careful inquiry about its efficacy at those schools where it has been tried, and let not such inquiry be confined to only the sponsors of the method. Perhaps no real harm can come from a student's acquiring a smattering of terms and phrases in a diversity of rather unrelated subjects in a wide range of arts and sciences. But there is danger that the time demanded for exposing under classmen to too many such subjects will rob engineering curricula of the necessary hours needed for training students thoroughly in the vital studies of engineering. It is already understood by many of us that such studies are as essential to the attainment of genuine culture as they are to the development of thinking ability. Therefore let us guard jealously against any encroachment upon our vested rights in the students' time.

### Special Features of Certain Curricula

In the course of this study, there have come to light various especially interesting phases of electrical training other than have already been mentioned. Here and there special emphasis is laid upon certain subjects, or unusual methods of instruction are employed. It seems desirable to present these features briefly and without comment, arranging them merely by the names of the schools.

*Pennsylvania, University of:* "The undergraduate course is laid out with the idea of giving the student primarily a college education with a strong engineering slant, rather than a narrow professional training."

"A course of particular interest, and which is unusually popular with the students, is the course on current social and political problems. Each week in the second term of the junior year, a lecture is given by some outstanding member of the faculty of our School of Commerce and Finance on the particular phase of economics or sociology in which he is expert. At the end of his

lecture, a problem is assigned to the class, and the following week the faculty member meets the class and discusses the answers which the students have given to the problem."

*Washington, University of:* "Every member of the faculty is firmly of the opinion that Electric Transients should form a part of the basic training given to under-graduate students in electrical engineering."

*Wisconsin, University of:* "One distinct feature of the course is electrodynamics, given in the department of electrical engineering during the second semester of the sophomore year and the first half of the first semester of the junior year. This course is started after the students have had one semester of calculus and while they are taking the second semester of calculus. The students have quite an opportunity in the course in electrodynamics to make application of calculus to engineering situations such as the calculation of the potential differences and electromotive forces induced electrostatically and electro-magnetically in demonstration telephone and power lines, etc."

"The Board of Inquiry Method of Education is being tried for the first time in sophomore and senior courses. The theory underlying this method is that it should develop powers of free oral expression, since small groups of 6 or 8 students are formed in which much more opportunity for discussion is provided than is possible in the more usual recitation section."

## Conclusions

Not all engineering teachers are progressive. Too often, older deans and department heads are excessively conservative, feeling that the processes that have seemed to work for many years should be amply satisfactory and should not be disturbed. Thus we find that radical experimentation in engineering education is exceedingly rare. But the world moves on at a fast pace. Not only are rapid changes in material things occurring, but in these times, deep underlying foundations of the social structure are being subjected to severe scrutiny. Is engineering education keeping pace? Is it training for the best citizenship? Is it training for leadership in industry? Is it even training for the most effective service to society? These are all questions of tremendous import to America. They are so vital that if an unequivocal "yes!" could be given as the answer to each of them, it would afford boundless gratification to every conscientious engineering teacher.

# TRAINING ENGINEERS FOR THE MINERAL INDUSTRIES *

By ROBERT A. BAXTER

Colorado School of Mines

Within each educational institution the conflict between intensive and extensive work is one which never ends and on which any definite conclusion is almost impossible to reach. The student seems to be attracted by extensive summaries, while the instructor who likes to conduct and to direct research is often guilty of too much emphasis on his own particular line of work. Presidents, deans, and members of curriculum committees are more familiar with the shifting and rearranging which is done to keep these tendencies in balance, but every instructor should endeavor to familiarize himself with the problems of correlation and integration as they apply to his institution.

For instance, at the Colorado School of Mines we have set for ourselves what might seem a very definite objective of training engineers for the mineral industries, yet we have four distinct curricula with several subdivisions in these main branches.

I am making a general description of our curricula, because, as far as I can find, ours is the only institution limiting itself entirely to the work of the mineral industries.

The original objective of a course in mining engineering has been broadened to cover the following four phases:

1. Finding the mineral.
2. Extracting this mineral from its location.
3. Concentrating it and transporting it to where it can be used.
4. Purifying, refining or converting it into a usable form.

In covering these various phases, the student is given a choice of one of the following four options, each of which has subdivisions: Geological, Mining, Metallurgical and Petroleum Engineering. The geological division is concerned mainly with the first of the phases, namely, the finding of the minerals as they occur. In later years this work has been made quantitative by the introduction of geophysical methods of measurement, which have grown to such importance as to necessitate a separate department. The mining department and the production option within the petroleum department are concerned mainly with the second proc-

* Presented at the 39th annual meeting, S. P. E. E., Purdue University, June 17–19, 1931.

ess, that of removing the materials from the earth. Both of these lap over in each direction through the discovery of additional minerals by drilling and tunneling and through the concentrating and preliminary purifying necessary in order to convert low grade minerals into materials worth transporting. The fuel engineering option has been chiefly concerned with the second and third processes but is beginning to expand into the fourth through attention to the matters of carbonization and gasification of coal and related materials. Both the ferrous and non-ferrous options under the metallurgical division and the refining option under the petroleum division are most directly concerned with the fourth process, that of converting the raw materials into forms in which they can be more readily used.

Courses for upper classmen are given under the direct supervision of each of these departments. There are preparatory and collateral subjects given in other departments which do not confer degrees but may offer graduate work as well as undergraduate work in pure science or its applications. These other departments comprise such divisions as Mathematics, Chemistry, Physics, Languages, Drawing, Economics, and Mechanical, Civil and Electrical Engineering as applied to the mineral industries. Formerly degrees were offered in the latter three branches and in Chemical Engineering, but in recent years it has seemed advantageous to concentrate all our attention on the problems directly connected with minerals and their recovery and utilization. This does not mean that we believe that men trained in this manner must stay within the limits of this field or that none trained by other methods can enter it. It does mean that we believe that the finding, winning and refining of minterals is a sufficiently large phase of modern life and sufficiently inter-related that courses can be pursued with profit by young men desiring engineering positions in that branch of human endeavor.

In order to complete a program of the presentation and correlation of the necessary fundamental principles within a period of four years, it has been necessary to make a very closely prescribed sequence of courses in each option, thereby eliminating most of the privilege of election of courses after the particular option has been chosen.

The work of the first year is the same in all options and involves General Chemistry and Qualitative Analysis, Descriptive Geometry and Engineering Drawing, English Composition, Elementary Mathematical Analysis, General Geology, Military Science and Physical Training. It is followed by a six weeks summer course in plane surveying.

In the second year all men take two semesters of Physics and

two of Calculus and one semester each of English Literature, Quantitative Chemical Analysis, Mineralogy, Mineral Land Surveying, Graphic Statics, and Analytical Mechanics. The petroleum men get Organic Chemistry and Economic Geology, the geology and mining men get additional mineralogy, and the metallurgy men get Structural Geology and another course in quantitative analysis.

In the third year the separation into the special options is more marked but all men take Physical Chemistry, Technical Exposition, Industrial Organization, Thermodynamics, Mechanics of Materials, and fundamentals of Electrical Engineering. Near the end of the third year all men get First Aid and Industrial Safety work under the direction of men sent from the U. S. Bureau of Mines during a two weeks period. At the end of the third year all men get summer laboratory or field work in their appropriate options for a period of three to six weeks.

In the fourth year all students take Engineering English, Principles of Economics, and Contracts and Specifications, but their technical courses vary with the different options. Near the end of the Senior year an inspection trip of two weeks duration is taken by the mining and metallurgy group and another similar trip by the men in the petroleum option.

A survey of the catalogs of other institutions and conversations with instructors and administrative officers indicate that the main difference between the training of engineers for the mineral industries and of those for other industries lies in the greater amount of geological work which must be coördinated with the other physical sciences and the greater emphasis on tracing of minerals from their location in the ground to the usable products which may be prepared from them rather than on particular materials or processes.

In conclusion I may say that the objective should be to train not scientists, not technologists, and not tradesmen, but men who will have a sufficient knowledge of the fundamental physical sciences and a concept of their application such that within a reasonable time they may successfully apply these principles to the engineering problems peculiar to the mineral industries.

# THE CASE PROBLEM IN ENGINEERING EDUCATION *

By F. A. KARTAK

Dean of Engineering, Marquette University

In bringing before you a brief discussion of the procedure and results obtained by my associates and myself in the use of the case problem method in some of the junior and senior courses at Marquette University, I feel that I can, perhaps best illustrate the objective at which we are aiming by quoting from the paper which Professor Jackson presented from this platform day before yesterday. In discussing the need for developing an investigatory spirit in the engineering student, Professor Jackson said: "The crystallized hindsight of the printed textbook page and the conventionalized classroom lecture, do not alone stimulate most minds to the necessary effort; but a ready instrument for such stimulation lies in the practice of investigation carried out under sympathetic council and direction by suitable leaders."

It was with precisely this thought in mind that some years ago we turned an introspective eye upon our own work seeking for a rational and effective solution. The result has been the adoption of the case problem method in certain of our courses, such as Industrial Finance, Engineering Law, Production Engineering, Industrial Management and in certain courses in Electrical Projects. We feel that the development of an investigatory spirit is not limited to seminar courses and experimental work but may be properly developed even in such courses as I have mentioned of which some like Law and Finance and Management have usually been looked upon as purely classroom courses. We have found in the case problem method an effective tool to this end. It may be well to state at the outset that this paper, in discussing the method of the case problem, does not in any manner claim a pedadogical innovation. The case problem is as old, probably, as education itself and hence would not justify exposition on the grounds of novelty. In the opinion of my associates, however, it is believed that the results as applied to this particular field of engineering education deserve discussion and perhaps serious consideration.

It is not at all singular that in spite of the age-old character of the case problem, it has been, relatively speaking, little used. It

* Presented at the 39th annual meeting, S. P. E. E., Purdue University, June 17–19, 1931.

may be well to attempt an explanation at this point, which in turn will assist in laying before you more clearly our opinions. The case problem method has been little used, first, because it is obviously difficult to obtain the necessary and satisfactory data; second, because it demands an enormous and exhaustive amount of labor from the instructor; third, because success by this method is impossible if placed in the hands of young and inexperienced teachers, and, fourth, because engineering students, generally speaking, have a too meager industrial background necessary for facility and ease in the manipulation of the case problem method. Where industrial experience is demanded by the educational authorities either through summer vacation work or coöperative apprenticeship, this difficulty is proportionately reduced.

It may well be, as the Committee on Instruction in Industrial Relations reporting for the S. P. E. E. declares that, "even with thoroughly experienced instruction and with students who have progressed far, the use of *actual cases* of major managerial situations as class problems involves serious danger of superficial treatment." Nevertheless, in developing the case problem method in the College of Engineering, Marquette University, the faculty was convinced at the outset that the *actual case material* made available to the student in his coöperative engineering apprentice work, alternate months, in the industries of the Milwaukee district, provided such splendid material right at hand that the use of this method of instruction in such senior courses as Industrial Management and Production Engineering, Industrial Finance and Engineering Law as well as the junior course in Electrical Problems, was wholly justified. The results, it is sincerely believed, provide a definite affirmative answer, making it clear that under these conditions the case problem is wholly justified. As a statement of corollary relationship, the following conclusion would seem to be warranted; *Whenever engineering students of the upper classes have achieved a sufficient industrial background either through prescribed summer vacation work, or otherwise, the case problem method becomes a potent educational tool, providing teachers and faculty are willing to make the sacrifice.*

Such engineering students, enjoying this background of vital experience, will be greatly benefited if the industrial management problem in material handling, an engineering law problem in accident compensation, a corporation finance problem in working capital, or an electrical problem in transmission of power under these circumstances of background and experience proceeds to fashion the material the student handles daily, as it were, in his industrial work. Obversely, such class-room work must of necessity be a far more vital and living thing in the reflected light of such experience.

In order to clarify our procedure, I propose to describe briefly the functioning of the method in a few of our courses. A more complete insight into the details may be had by examining the exhibit which has been set up in the Reception Room on the first floor of the Memorial Union Building.

It was with these thoughts in mind that some of the faculty of the Engineering College made application of the case problem method. In the present paper the method as applied to Electrical Problems, is considered separately; likewise as applied to Engineering Law and Industrial Finance, and Industrial Management and finally to Production Engineering.

## Electrical Projects

Professor Douglas of our Department of Electrical Engineering has had considerable success in developing a course of Electrical Problems of a project nature and I believe a description will be of interest to you. The course of problems, as developed in the Electrical Engineering course at Marquette University, runs through four semesters in the fourth and fifth years for a period of forty weeks of time in school. The time involved in the curriculum being thirty-three exercises of four hours each and twenty-one exercises of three hours each. In that time ten or eleven problems are assigned of varied character, and of graded length and difficulty. The shortest problem occupies eight and the longest forty hours for its solution. The total credit allotted is four and one-half semester hours.

The problems are laid out in such manner that most of the reference material may be obtained from one of the electrical handbooks, together with the texts used in the recitation classes. We hold no brief for the handbook as a source of entirely up-to-date data but regard it as a useful starting point when first entering project work.

The following table shows the titles of problems that have been used with the time allotted for their solution:

| Prob. | Time Hrs. | Title |
|---|---|---|
| 1 | 16 | Lay-out of Interior Wiring for Light and Power |
| 2 | 12 | Selection of Units for a Compound Speed Regulator |
| 3 | 16 | Selection of Motive Power for a Machine Shop |
| 4 | 16 | Predetermination of the Performance of a Synchronous Motor |
| 5 | 8 | Study in the Economy of Synchronous Condenser Installation |
| 6 | 20 | Lay-out of distribution Wiring for Area of Fourteen City blocks |

| | | |
|---|---|---|
| 7 | 16 | **Design of a Transmission Line** |
| 8 | 12 | **Design of a Choke Coil** |
| 9 | 16 | **Design of a Lifting Magnet** |
| 10 | 40 | **Design of a Direct Current Generator** |
| 11 | 42 | **Computation of Schedules, Power Consumption, and Sub Station Capacity for an Interurban Railway.** |

It is to be noted that these problems are not short although from the title some of them might be considerably abbreviated . The data is not over-complete and a number of issues must be settled and a number of considerations brought to bear before a solution is obtained.

One sheet of mimeographed instructions is issued for each problem. These state the problem, furnish the data, indicate a sequence of procedure which is economical of time, but do not give detailed instructions which might make the work too mechanical. Oral guidance is given the student when required, chiefly in the form of personal interviews. The mimeographed notes contain two sheets of supplementary engineering data comprising information not available in texts or handbooks; in certain problems the data as furnished includes a plan or map.

In the latter problems little originality can be claimed as the student is directed to Still, Kuhlman, Moore and Gray's books on Design and Harding's book on Electric Railway Engineering. The task here has been one of selection. We believe that most of the principles really worth while can be obtained from designing one stationary and one revolving machine. It is to be observed that the earlier problems are not strictly design since equipment and material already manufactured are to be selected and arranged. However, they have some important and valuable points in common with design. First, they deal in concrete applications; second, they attain a definite practical conclusion and recommendation; third, some study and appreciation of economic factors is required. Thus, the student is put into the attitude of the engineer for a company purchasing power, of the engineer of a public utility, of the consulting engineer, as well as that of the engineer of a company manufacturing electrical machinery or equipment.

The course is administered so as to wean the student from dependence and develop initiative and self-reliance. This objective is obtained, of course, in varying degrees. A marked development of self confidence is noted in even the most diffident.

This perhaps is the most clearly marked benefit of those who take this course. Other benefits are:

(1) Students acquire an increased grasp on engineering principles.

(2) Students are led to think concretely and develop economic judgment.
(3) Students absorb a considerable amount of handbook material and data from other sources.
(4) Students have a survey of the application of electricity over a large field.

We believe that the benefit secured is greater in proportion to the time spent than in perhaps any other electrical course, and that time can be diverted profitably to the solution of electrical projects, provided fundamental theory and laboratory are adequately handled. In support of this thesis the following points should be considered: (1) A principle is not thoroughly grasped until it can be applied; (2) It is better to have a sufficient number of useful principles that one can apply than a greater number that are improperly assimilated; (3) A subject is not fully learned when first learned, but by repetition with diversity of viewpoint, mastery of a subject is secured; (4) Project and design worked together with theory and laboratory are the three most essential modes of approach to the subject matter of engineering; (5) That some appreciation of costs is essential in getting a good engineering judgment.

Project work is an essential element in engineering instruction; theory is to be regarded as training in deductive reasoning; laboratory may be regarded as training in inductive reasoning; but in both the student is absorbing and not giving forth. Project work affords an opportunity for self-expression which, after all, must be exercised to be developed to the point of utility needed by the practicing engineer.

### Production Engineering

The course in Production Engineering requires somewhat different treatment inasmuch as one problem is sufficient to occupy the efforts of an entire group of 12 to 15 students.

Production engineering as a subject in the College of Engineering can best be explained by a brief and summary reference to the actual problem assigned for the school year 1930–31. A complete set of blue prints, charts, and tables appear in the exhibit which will facilitate this reference and render this explanation more illuminating.

The assembly and parts drawings concern an indexing fixture for use with a milling machine. The fixture has been manufactured in Milwaukee and the drawings are those actually used in production.

After having considered the principles of production engineer-

ing during the last half of the junior year, the senior student is now required to take these drawings in hand and proceed as follows:

1. Make a detailed job analysis of each part, as well as the assembly.

2. From the job analysis determine the kinds of machines and equipment, machine loadings, and machine groupings.

3. These first two steps lead easily to the basis for flow charts of both materials and operations.

4. The next step demands the design of an industrial building which will adequately include all other machines and equipment, with due respect to the human element naturally involved.

5. The four previous steps lay the foundation for the determination of an exact figure of manufacturing cost.

This latter involves:

(*a*) Numbers employed for direct labor and rates of pay.
(*b*) Amount of indirect labor including supervision and inspection.
(*c*) Cost of land, building, and equipment.
(*d*) Determination of capital investment and necessary working capital.
(*e*) Detailed analysis of depreciation, insurance, taxes, interest charges, and all other items of indirect expense.
(*f*) Estimate of unit cost based on a predicted production rate.

It will be noted that the latter phases of this problem are almost entirely economic. We consider this to be a very vital part of the course because the relation of indirect expense to manufacturing cost is so important and is so clearly illustrated in problems of this character.

Students are assigned in groups or teams to various phases of this work, a method which is necessary both because of the number of students and the scope of the work, in each phase.

Conferences with individuals and groups can be the sole method of teacher contact; class work is impossible.

Much emphasis is placed upon initiative in attack, self-reliance, and the ability to ferret out the proper information in the right place.

It is interesting to note that the grouping of students immediately calls forth qualities of leadership within the groups which might otherwise remain unknown to the engineering faculty.

### Management, Law, Finance

In the courses in Industrial Management, in Industrial Finance and in Engineering Law, all of which involve two semesters of time, the first semester's work in each subject is devoted to a textbook

treatment in order to establish a working basis for future attack. About thirty lectures or class meetings in each course in the first semester are devoted to this treatment.

In these thirty or more lectures in each course the fundamental principles are presented. Some assurance of student coöperation is secured by announcing at the very beginning a written review of the whole subject at the end of the first semester.

Immediately after the beginning of the fall term, case problem assignment is made, one case problem representing a major division in the principles of finance and of law to each student. For the school year 1930–31 five projects were chosen, each an actual going concern, though the names were changed for obvious reasons. These five problems included two types of marketing organizations, two types of manufacturing corporations and a municipal corporation. Each student in developing the material for his case problem is permitted, and even required, to make necessary assumptions, though these must in every instance be reasonable and justifiable. This is best explained by referring to the case problem involving "bankruptcy." All of the concerns chosen are going concerns; hence, the student assigned the problem of considering bankruptcy must precede his presentation by a statement of assumed conditions justifying a bankrupt condition of the organization with which he is dealing.

The written reports representing these assignments are demanded shortly before the conclusion of the first semester's work. These reports are then mimeographed and a copy placed in the hands of each member of the class one week before the presentation, which takes place before a committee of the faculty composed in some instances of representatives not only of the College of Engineering, but also of the College of Business Administration. Usually two papers are presented at a given class session according to a predetermined schedule.

Each member of the class is required to submit at the beginning of each class period a brief written criticism of the papers to be presented. The student making the presentation is placed in the position of an executive or director of the company he represents, reporting to a joint meeting of stockholders (students) and board of directors (faculty). He must defend his position before this joint group, and he is judged not only by the excellence of his paper, but by his ability to defend the conclusions he has reached and the recommendations he has made. The class members in turn are judged by the nature of their written criticisms and the intelligence of their attack or questioning of the presentations. It is to be noted that inasmuch as advance copies of the papers are in the hands of the class, the papers presented are not usually read

in full, but are presented in abstract by the authors, which gives training in practice of this kind.

The preparation of reports demands individual conferences between student and professor. Suggestions alone, however, are offered, the student being forced in each instance to consider his particular problem a matter for personal research, attack, and solution.

In general, the same projects are used for Law as for Finance—the connection and relationship is obvious. Thus, the same company for which capitalization and working capital have become a matter for student consideration and report, lends itself admirably to a consideration of the subject of agency, contract, compensation, or leases.

We feel that a distinct step in advance has been made by the adoption of this method in these respective courses, based not only on observations of the manner in which the principles become more firmly fixed in the minds of the student, but by the favorable reactions of graduates who have had the opportunity to look back over the work in the light of a few years of contact in the profession after graduation.

It is a plan which, because of the time necessarily devoted to much individual conference work, can bear fruit only when the instructors are willing to make this sacrifice in time, and which demands the services of mature and experienced instructors. With these conditions granted the results produced are most gratifying. To recapitulate then, we believe that the following summation of results represents a frank and conservative statement of achievement.

1. The theoretical principles are applied to actual problems of existing industrial material in a very similar, if not exactly alike, manner in which the engineer in industry applies theory to the problem in hand.

2. The scientific attitude of mind is thus cultivated; that is, the student is taught an orderly and logical mental approach to actualities.

3. Much individual conference work is necessary between the student and instructor in the use of this method; hence, better teaching results.

4. Each student is provided with individual work; self-reliance, independence, personal attack and many other desirable characteristics have an opportunity to develop within the student.

5. The case problem method of education establishes a liaison between classroom and industry, and, hence between theory and practice.

6. This method prevents petrifaction of the professional mind;

the necessity for alert, constructive and vitalizing teaching is obvious.

## Discussion

**W. H. Timbie,** Massachusetts Institute of Technology: Right at the start I want to congratulate Professor Kartak on the excellent piece of work that he has done in arranging and carrying out these projects, and upon his interesting presentation of the plan. The method has apparently accomplished excellent results in this case and for just that reason I want to put in a word of warning. Professor Kartak has wisely applied this case method to courses of a certain type only and not to the courses in electrical engineering. Because the plan has worked well with these courses does not mean that it should be adopted in engineering courses.

As I see it, the case method is at best a substitute for a real scientific orderly presentation of a subject. Those subjects in which the material cannot be effectively organized in this way have to be treated by some other method, and the case system is a perfectly logical way of doing this work. It is really the method by which we acquire most of our information and experience after we leave school. We are interested in a case or a project and naturally have to look up all the information available concerning it. It does not follow, however, that this is the best way to obtain unified knowledge of scientific engineering subjects. The real reason why we have educational institutions is because they afford organized courses of instruction which are not available in practice. The scientific organization and presentation of such courses, wherever the material lends itself to such treatment, is the very thing that makes it possible for a student to acquire in four years a unified knowledge of scientific principles which, by the ordinary course of experience (*i.e.,* the case method), would require a good part of a lifetime.

Take, for instance, the organization and arrangement of the subject material in the electrical engineering course at M. I. T. A unitary thread of electro-magnetic theory is made the backbone of the course, consisting of the study of theory supplemented and clarified by laboratory work and by the solution of applied problems. This is buttressed by courses in English, Mathematics, Physics (with its Applied and Theoretical Mechanics), Chemistry and Political Economy. These subjects have by years of experience been so analyzed and organized that in the very studying of them the student not only acquires a certain amount of valuable information, but, what is vastly more important, he learns the engineering method of thought and procedure.

It is all very well to use the case method in courses of Business

Management where the material cannot be effectively organized, and in courses in law, where the work consists largely of tracing precedents, but I feel it would be a decided backward step if we tried to adapt this method of instruction to courses in science and engineering which have been proven to be so capable of more systematic organization and presentation.

**Arthur G. Anderson,** University of Illinois: The older curricula in engineering colleges well illustrate the *problem* method of education. In civil engineering courses, for example, problems predominate. Physics, chemistry, surveying, structural design, hydraulics, railroad engineering and water supply offer good examples of problem courses. As a consequence, engineering students learn to do those things which they are later called upon to do, to use fundamental knowledge and principles in getting technical results. They are at the same time disciplined by hard work, accustomed to attaining definite objectives each day and to getting accurate, provable answers. Both teachers and students know exactly where the latter stand at any moment, as far as progress goes and the worth of the completed work.

Dean Kartak's paper portrays efforts to carry this method of teaching into other curricula, with modifications to adapt it to the different situations confronted. Others have gone even farther than he has, and we have the case method used to teach business administration, and law. There are weaknesses to the method, which Dean Kartak and his associates have recognized. The students taking the courses we have learned about are fourth and fifth year students with training and experience in factories. The teaching staff are mature, qualified, and evidently appreciative of the extra time required for successful teaching of this kind. Adequate, definite data have been available as material to work with.

During the past few years I have witnessed the application of the case method of teaching in a number of courses where these safeguards to effective work did not apply. Business and industrial problems are not easy ones to solve. Inexperienced teachers, however learned, are likely to deal with them superficially, and students to get erroneous ideas of how business judgments are arrived at. A graduate of a school where the case method is extensively used tells me that actually more emphasis was placed on the student's ingenuity and resourcefulness in handling the material available to him and less on the definite conclusions reached. We are inclined, rightfully I think, to place more emphasis upon the answer arrived at. In teaching business law I note a tendency toward education in principles and use of problems as a check upon ability to apply them. This seems to be good teaching practice.

Engineering curricula have been criticized as neglecting the

executive, economic, and human relations side. Professor Palmer in THE JOURNAL OF ENGINEERING EDUCATION for May writes:

"The engineer deals not only with things but with human beings. Some of his biggest problems are in connection with what he calls human engineering. As he usually aspires to the holding of an executive position, he must learn to know men and how to handle them. The higher his station becomes the more he realizes that for him tact is greater than talent. And, from sheer necessity, he must leave more and more of the purely technical matters to his subordinates and devote his own time mainly to human and business relations."

The courses under discussion are evidently designed to provide a balanced training of the kind suggested. The student needs to contact with business people, to locate, to gather, and to interpret and evaluate data. He then needs to present this in report form. In doing all this he gains experience in learning what data to discard, what procedures are not advisable and why, and in general what not to do as well as what to do. If his presentation is questioned, he should be able to defend it. I surmise that in these courses students are at first likely to underestimate the time and thorough work required to reach conclusions not expressed in definite figures.

A study of the problems indicates a need for thorough basic understandings of the subjects, and considerable information of a general nature in order to deal with them. This is as it should be. They thus represent the student equipped with training and intelligence actually functioning under skilled and critical supervision. This, for the student, is a crucial test, for the ability to make constructive use of knowledge is the final test of education. The problems in general do add executive, economic and human considerations to technical questions.

Problem courses *are* interesting and that is likewise a valuable characteristic of them. They stimulate enthusiasm and add to appreciation of the aims of teaching and of the worth of the teaching.

**Mr. Thompson,** Proctor & Gamble: May I suggest that some of the measures of the case method are due to the fact that it is automatic curriculum instruction, and that a curriculum constructed of cases of recent origin has to be alive.

If textbooks and courses were built up by methods which would make them pertinent to the practice of engineering, as the cases are; if those principles were kept in mind when professors make textbooks, the case method would not be getting ahead quite so fast.

**D. C. Jackson,** Massachusetts Institute of Technology: This paper of Professor Kartak, which is a very interesting one indeed, associates very closely with certain comments that arose in Pro-

fessor Wiley's paper and Professor Moore's comment on it. I think that is the root of the situation. In fact, I judge from what Professor Anderson says that Professor Kartak doesn't intend that we should fling ourselves into the maelstrom of the case system and forget the effective and systematic development of curricula regarding which Professor Timbie spoke.

Professor Wiley in his paper, which was on marking—but we will pass that by; we are talking about Professor Kartak's comments—said that they start out when they are beginning to work out the problem of grading with an effort to secure an effective understanding of the scope and philosophy that underlies each subject to be taught, that understanding to be on the part of the instructors.

That is one of the things that is most difficult in the whole business. There are a lot of difficult things, but that is one of them. The younger men are approaching a situation that we have not reflected on. They must be given time; in fact, required to take the time to reflect upon it, but after some of the older men who are masters in their particular subjects have been teaching three or four years on the basis of an assumed thorough knowledge of the setting of their subjects in connection with a group of subjects, it will be found almost invariably, if they are competent and able, that they have become so wrapped up in the unfolding of their own that they have forgotten it contacts all around, and particularly at the ends, and the whole thing has to be stirred up once more in order that the electrons of thought may circulate in such a fashion that the atomic and molecular structure shall stay whole.

Now that comes to one of Professor Moore's remarks that I do not believe we ought to pass over without commenting on, that any of us ought to pass over without commenting on. He said that the students come to us with a given amount of intelligence and they go away with the same amount of intelligence. I know the psychologists say so.

I am willing to go along with him on the hypothesis that they come along with a certain amount of latent intelligence and go out with the same aggregate intelligence, but I insist we can gather some of the latent intelligence that has not become dynamic and transform it into a dynamic characteristic and that, after all, is our part. If it were not otherwise, we would be admitting a policy of defeat. We might as well be just rubber stamps, sort of putting a figure here and there onto an already developed intelligence.

Are we after B men? Not on your life! B men are not needed in the world as much as the H men on that list, but they are needed in much larger numbers. After all, aren't we after developing all the dynamic intelligence that is possible by bringing some of the

men who might, with the ordinary basis of instruction, remain B men through the development of their intelligence into the dynamic form so they will be H men and have much more weight in the world in proportion to their physical numbers than they might otherwise have?

We don't care about numbers. We know we aren't graduating too many men. We might graduate more. After all, it isn't the B men we want to keep B men, but we want to prevent them from being B men. I would rather have a lot of my B men become F men and have some of them become H and A men than to have them all stay B men. I don't want any of them to be C and F men, but if I had to make the choice between having a lot of them turned downward and a few turned upward for one choice, and the other choice to keep them mediocre, median, I would take the first course. As a matter of actual fact, it isn't necessary to make that choice. You can stir a lot of the B men up into the A and H ranks by developing in dynamic characteristics the intelligence they have.

I will pass on to you an old thing that I get off to my own closest friends, and my own staff as far as that is concerned, frequently because it is not only old with them inasmuch as I have put it at them so often, but it is old in the world; that is, after all, human beings are awfully stupid. They are all awfully stupid. The real problem is for each man to try to be a little less stupid than the rest, and then he will be a distinguished man. In other words, get a little more of this intelligence that he came into the world with, about which the psychologists allege there is a conservation, into the dynamic form.

I will also venture that this allegation of whatever the psychologists may have demonstrated about the conservation of the aggregate of intelligence has a factor that no proved psychological principles can convert, and that is if there is only a unit amount of intelligence in each man's mind that intelligence can be modified in its form by proper study and preferably by proper study under proper guidance.

**A. M. Dudley,** Westinghouse Electric and Manufacturing Company: I am even less modest than Dr. Jackson because being a mere industrialist I dare to raise my voice in this assemblage, but there was something that Professor Bryant of Minnesota said to me last night that I think might clear some of the atmosphere about practical work and case problems.

I am with Professor Timbie one hundred per cent on the fact that our real job is to get across fundamentals. However, we are all human beings and we understand the concrete more easily than the abstract. In this connection there is something that is older than the matter of case problems, and that is that you men

teach the actual design of dynamo electric machines. That is, you have a man actually calculate a dynamo machine in theory, when people who are building dynamo electric machines have said many times—"Please do not teach actual systems of calculation because in many cases we have to unteach a particular system and teach our own methods of commercial calculation." But it is of tremendous use to us to have you get across the theory of the electric circuit and the magnetic circuit so that when a man comes to work on design, involving those fundamentals, he can do it.

Here is the human reason why we cannot stick entirely to abstract fundamentals. These boys will not take these fundamentals purely as such without concrete examples. They have to see that they are tied in in some way with the everyday life they are living, and that they are tied in in some way in getting industrial results after they are out. I think that is the whole story. That is the reason somebody started to teach a boy how to design a lifting magnet, a transformer or an induction motor, because that fellow would not study the mere theory of the electric circuit and the magnetic circuit. It was too abstract. In other words, the student is reaching after the concrete.

Let's take these coöperative schools, for which I want to say right now I have the very highest regard, Cincinnati, Drexel, Marquette, Akron, and the other ones that are doing that kind of work. To a large extent the boys at those schools have to earn their own living. They are very practical fellows. They work with their hands and are sent out into industry. Immediately they say: "What has all this theory got to do with this practice we see going on here?" The case problem fits in there very well, indeed. It shows them where it all has a place and, I think, humanly speaking, that is why we try to teach the design of machines and that is why we rely on case problems to make it humanly interesting to study the theory they have to get.

But back and beyond it all, we must believe that we are here to give the fellows the tools and get them to take them the best way we can.

Since this meeting started somebody said that education involves the individual above everything else, and as educators we know we can't handle people as individuals; they have to be handled in classes. Somebody asked the other day, I think it was Mr. Krausnick of Akron, how much mathematics we should teach these engineers. Unquestionably, the more mathematics a man has that he can use as a tool, the better off he is. We know today a man must use his differential equations in certain places just as commonly as he used trigonometry twenty years ago. Some of us are suffering today because the real meaning and usefulness of

differential equations was not made clear to us as students by enough practical examples. Coming back to the individual, I think case problems are useful and the teaching of design is useful, because it shows the man where his theory fits into practice. I believe that is the answer to it, and that it must be done wisely. Professor Kartak has said he knows what the limitations are. He realizes that. These men using it know all these things we are saying, but we have to be wise and with Professor Timbie not go too far over on our Bantam Leg, as was said last night.

# CURRICULA FLEXIBILITY *

By W. C. McNOWN

Professor Highway Engineering, University of Kansas

The general facts surrounding curricula flexibility are well known to those who are connected with engineering education. They may be briefly stated as follows. The undergraduate period which may be devoted to training students to the point of receiving an engineering degree is normally four years. Whether such period is sufficient may be a question, but the several attempts that have been made to lengthen it have not been successful. Engineering is a rapidly growing art. New and valuable subject matter are being added continually. Entrance requirements to state supported schools are not high. Demands are constantly being made that the scope of engineering curricula be widened in the interest of culture and breadth of understanding. Modern civilization has been molded and developed to a large extent by the works of engineers giving rise to complex problems that are now everywhere discernable. Engineers are being called upon more and more for aid in problems that are social and at the same time highly technical. In the light of these and doubtless many other considerations it is natural that engineering educators should consider curricula content from time to time, sometimes narrowly and sometimes broadly.

It is desirable then to turn next to the content of our curricula and to consider its parts to see where flexibility might be introduced and to what extent. Flexibility of curricula implies the substitution of one subject matter for another. Is it possible to make such substitution in the curricula of our engineering schools? In consideration of this question use will be made of the standard curricula of the Department of Civil Engineering of the University of Kansas which follows in somewhat condensed form. Distribution has been made of the credit hours connected with each subject under the various headings. This tabulation needs little explanation.

Credit hours distributed into columns 1 to 4 inclusive are connected with subject matter which may not be substituted for the subject matter of other courses. Those placed in column 5, headed Collateral Subjects might perhaps be used "flexibly" under certain conditions, though opinions will differ as to which subjects

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UNIVERSITY OF KANSAS

Lawrence

*Civil Engineering Department*

| Subject | 1. Design Sequence Credit Hours | 2. Surveying Sequence Credit Hours | 3. English Sequence Credit Hours | 4. Fundamental Subjects not in Sequence | 5. Collateral Subjects | |
|---|---|---|---|---|---|---|
| | | | | | Tech. | Non-Tech. |
| Mathematics—5-2-5-4-4* | 20 | | | | | |
| Rhetoric—3-2 | | | 5 | | | |
| Geology | | | | 3 | | |
| Engineering Lectures | | | | | 1 | |
| Chemistry—4-3 | | | | 7 | | |
| Engineering Drawing—2-2 | 4 | | | | | |
| Descriptive Geometry | 3 | | | | | |
| Physics—5-5 | 10 | | | | | |
| Surveying—3-2 | | 5 | | | | |
| Technical Reports—½-½ | | | | | 1 | |
| Roads & Pavements and Lab. 3-1 | | | | 3 | 1 | |
| Applied Mechanics—2-3 | 5 | | | | | |
| Railway Surveying—2-2-2 | | 6 | | | | |
| Summer Field Work | | 4 weeks no credit hours. | | | | |
| Strength of Materials | 4 | | | | | |
| Engines & Boilers | | | | | 3 | |
| Economics | | | | | | 3 |
| Reinforced Concrete | 3 | | | | | |
| Elements of Electrical Engr | | | | | 3 | |
| Testing of Material Lab | 1 | | | | | |
| Graphic Statics | 1 | | | | 1 | |
| Hydraulics and Hyd. Lab.—3-1 | 3 | | | | 1 | |
| Non-technical Options | | | | | | 5 |
| Masonry & Foundations—2-2 | 3 | | | | 1 | |
| Stresses & Bridge Design—5-4 | 9 | | | | | |
| Reinforced Concrete Design | 2 | | | | 1 | |
| Water Supplies & Sewerage—3-2 | 5 | | | | | |
| Technical Option | | | | | 5 | |
| Masonry Laboratory | 1 | | | | 1 | |
| Seminar | | | | | | 1 |
| Advanced Composition | | | 3 | | | |
| Industrial Administration | | | | | | 3 |
| TOTAL OF CREDIT HOURS = 137 FOR GRADUATION | 74 | 11 | 8 | 13 | 19 | 12 |
| TOTAL PER CENT = 100 | 54% | 8% | 6% | 9% | 14% | 9% |

* Algebra ..... 5
Trigonometry ..... 2
Analytical Geometry ..... 5
Calculas I ..... 4
Calculas II ..... 4

might be considered collateral and which required. However for the purpose of this discussion we note that a total of 31 credit hours, or 17 per cent of the number required for graduation may with liberal interpretation be thought of as substitutable for other subject matter when it can be shown that such other subject matter has equal or greater value.

A similar analysis of the curricula of the departments of Electrical and Mechanical Engineering developed about the same percentage of subject matter available for such consideration.

The question for discussion constitutes a problem in engineering education. Whether it is a serious one perhaps further discussion will disclose. Furthermore it seems very doubtful whether we have the means at hand for use as a rational basis for this or any other problem in engineering education. It will be necessary to proceed along the same general lines as would be followed in the analysis of any other more or less complex question.

A rational method of analysis should proceed from a basis somewhat as follows:

(1) A comprehensive statement of the objectives of engineering education.

(2) Clear statements of the principles underlying engineering education, in other words, the philosophy of engineering education.

(3) A means by which the relative values of various courses, methods of teaching, and types of subject matter may be more or less critically compared.

It may be found that this is a large order; it is for someone to show that it can be done with less. As instructors we do not assign problems to students without giving them the substance for the solution. Yet though the Society for the Promotion of Engineering Education has existed for many years, a search through its Proceedings does not reveal that it has provided the substance for the solution of the problem under discussion.

It would be out of place at this time to attempt a detailed analysis of the three items named above as seeming to be essential as foundation material for this discussion. In fact it would be impossible to do so. Each item merits a separate presentation following a considerable amount of coöperative effort. In order, however, to lay the groundwork for further discussion they will be considered superficially.

The primary general objectives of engineering education is to train men for strictly professional engineering practice. If after receiving such training such men decide to use it for other purposes the responsibility is theirs. At the same time the broad implications of the term engineering education will be recognized. An attempt will also be made to interpret engineering education broadly in all its phases.

It should be made clear just what is meant by the term principles of engineering education. Engineering educators have long maintained an almost contemptuous attitude toward professional educators as such, and it may be that professional education has little to offer to engineering educators for use in the solution of the problems of engineering education. We may not know. But it does seem inconsistent that a body of men trained to solve their own problems according to a rational method should not make a more serious and concerted effort toward the development of an educational philosophy as a basis for the solution of their own educational problems. To be sure we have had our "fact finding investigation" but is any real use being made of it? Perhaps there is, the writer does not know.

From time to time we make changes in our curricula, taking out a course here and putting in one there, or reducing a course by one credit hour in order to be able to add one in another place. In some instances such changes may spell progress, as when we retire obsolete subject matter to make room for that pertaining to the more recent advances of the art; in other instances the objectives are not so clear. Changes are made following more or less unsupported personal notions or ideas. Sometimes such changes have been characterized by the work "tinkering." In any case it would seem that curricula changes should be made only from a background of impersonal educational leadership such as might be found in a well organized philosophy of engineering education.

A man prominent in engineering educational circles once said, "Oh, education is only a matter of common sense." But is that all? Common sense alone may not serve as a basis for the solution of complex questions, however valuable it may be as a check upon all manner of conclusions. Our legal procedure doubtless arose from a foundation of common sense, but it was soon found necessary to rear a structure of principles and rules of law to use with the facts in the rendering of decisions.

What is meant by educational principles? Speaking before this Kansas-Nebraska Section three years ago, Dean Shaad said, "It does not matter so much what we teach as how we teach it." In other words training and discipline are superior to subject matter in educational value. This seems to be a fair example of an educational principle, and one which if accepted may be brought to bear upon the question of flexibility of engineering curricula.

As an air in carrying forward the discussion we may venture to present another. It is that subject matter, as such, should be accepted into the curricula only upon the basis of its educational value, and its corrallary is that, no subject matter should remain in the curricula while other subject matter of higher educational

value remains outside. And neither the proposition or its extension may be applied without refining somewhat our ideas as to what constitutes educational value.

What do we mean by educational value? For an answer we will refer to our objectives. What are we trying to accomplish, not in general, but specifically and in detail, in connection with any particular subject matter? Subjects that present another kind of training or, new and valuable tools that may be used in the solution of professional problems, or new and valuable ideas, are preferred additions to our curricula, while subjects that are descriptive, or that may be mastered by a trained mind, if and when, it ever becomes necessary, should rank low in the scale of educational value. And what applies to whole courses of study, applies as well to parts of courses.

Departments have been criticized for undue domination of the subject matter of the curricula of their particular branch of engineering. It is easy to see how this has come about. Administrators and faculties have been slow to deny additions to curricula that department representatives have offered as desirable for the training of men to practice their branch of engineering. There are some things to be said about this matter. First, the criticism is not my own. Further, if flexibility is something to be desired it can not be had with a curricula filled to the brim with rigidly required professional subjects. And then finally one way to correct the fault, if such there be, would be to check all additions to curricula rather carefully against the detailed objectives of our branch of education. We may assume that no one really desires an unbalanced curricula, the difficulty at the present time being perhaps that we may not know just what constitutes a balanced curricula.

Curricula flexibility has different phases. The student may be allowed options in the matter of courses in his own particular branch, as for instance between the structural or sanitary branches of civil engineering. Provisions for such options of course leads to smaller class room sections and may increase the cost of instruction. Choices may be allowed in the subject matter of two different branches of engineering, as between mining and civil engineering, or between civil and mechanical, or otherwise as the case may be. And lastly it should be possible to allow further work in the outlying departments so as to permit students to take more work of a semi-professional or cultural nature. Such semi-professional subjects as accounting, business law, business organization, public speaking and the like, have well recognized value.

While it must be recognized that a general and a professional education cannot be obtained by the average student in a four year period, engineering educators have commonly been willing

to allow some latitude in the direction of general education by allotting a certain few credit hours to non-technical electives. Here the objectives are the gaining of ideas in other fields of knowledge than that of engineering. However, when the student attempts to elect work in outlying departments he usually finds his choice limited to the elementary courses and his opportunity also limited to the gaining of relatively few major ideas. Much more might be accomplished if the leading departments would prepare to present more general courses covering their whole field instead of limiting the enrollment possibilities of the engineering student to the sequence of their particular departmental curricula. The experiment in progress at the University of the University of Chicago which includes just this idea should be watched with interest. Their plan is to have undergraduate courses in which the instructor presents all of the major ideas of his branch of knowledge, as say history, economics, biological sciences, or otherwise. Such treatment of the subject of economics should be of special interest to engineering educators who have long considered it either as a required course or as a preferred elective. When extended to include the major ideas of the whole field of economics it should be a more valuable course.

Whether further study of curricula would result in a desire for more or less flexibility no suggestion may be offered at this time. It is quite as likely to be less as more. What is far more important just now is that the attention of engineering educators be focussed upon the idea that they have made little concerted effort to formulate a definite educational philosophy to serve as a basis for guidance in connection with this and other questions of educational policy. Under such guidance the refinement of an already sound educational procedure should be less difficult.

# THE ADJUSTMENT BETWEEN SECONDARY SCHOOL AND COLLEGE WORK IN MATHEMATICS *

By JOHN W. YOUNG †

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From the point of view of our problem the secondary school is a preparatory school. It is well to emphasize at the outset that from its own point of view the secondary school is more than this: College preparation is only one of its functions, and not its most important one.

The question as to what constitutes adequate preparation for college work in mathematics can, of course, be answered only after the level at which college instruction in this subject is to begin has been determined. College teachers of mathematics, and especially those in engineering schools, would like to begin their instruction at as high a level as possible. The engineering curriculum suffers serious dislocation by the fact that only in rare instances can the subject of mechanics be begun before the Junior year. To move it back into the Sophomore year would require that the calculus be taught in the Freshman year, and this, in turn, under prevailing conditions would require that some of the usual freshman work in mathematics be disposed of during the preparatory period.

President Lowell of Harvard in a recent address has seriously criticized our system of elementary education on the ground of the time wasted. He is reported to have said: "In the secondary school we study what should have been finished earlier; in college we do what should have been done at school."

He is probably correct in this criticism. But no one at all familiar with present conditions can believe that any immediate improvement can be hoped for. The time may come when analytic geometry and the calculus will be taught generally and adequately in our secondary schools. I hope it may—the National Committee on Mathematical Requirements some ten years ago recommended that courses in the calculus be introduced into our stronger secondary schools. A few schools are indeed experimenting successfully with such courses.

* A lecture delivered before the Mathematics Session of the Summer School for Engineering Teachers, University of Minnesota, September 4, 1931.

† Professor Young's death, on February 17, 1932, occurred when the lecture here published was in galley form awaiting correction. The proof has therefore been corrected by the Director of the Summer School.

But it will, at best, be a long time before it will be feasible to raise our college entrance requirements materially as to quantity. Such curriculum problems as that referred to in mechanics will have to find their solution elsewhere than in raising requirements for entrance quantitatively. I expect to discuss such problems in a later address. For our present purpose I propose to assume that solid geometry, advanced algebra, and plane trigonometry form the upper limit of entrance requirements in mathematics and to discuss the problem of adjustment on this basis.

On this assumption is the present situation satisfactory? Are our entering students adequately prepared? On the face of the returns the answer to both questions is an unqualified, NO! The number of eliminations in our engineering schools is very high. Forty per cent of the freshmen fail to survive into the Sophomore year. While all this mortality cannot be charged to poor preparation, statistics in Bulletin No. 2 of the Investigation of Engineering Education assign nearly 70 per cent of the failures to lack of ability, lack of interest, and poor preparation. These figures are all the more startling when taken in connection with the fact that "engineering colleges are receiving considerably better than an average selection (of high school graduates).* This indicates that there is something radically wrong. On the face of it, either high school graduation standards are very low, or college standards are too high, or both.

I propose now to attack specifically the problem of reducing the mortality among classes entering our engineering schools. Logically there seem to be just three possible methods other than that of lowering our college standards.

More effective means of keeping the unfit from entering—*i.e.* better methods of selection.

Increasing the percentage of high school graduates who are adequately prepared—*i.e.* improving the quality of instruction in secondary schools.

More effective means of treating students after they have entered the engineering school.

## Methods of Selection—Entrance Requirements and Their Administration

A more careful scrutiny of the statistics published in the Bulletins referred to reveals certain significant facts.

**Conditioned Students.**—Twenty per cent of all students admitted are allowed to enter with conditions, some thirteen per cent with conditions in mathematics. This raises my first question:

* Bulletin No. 1 of the Investigation of Engineering Education, page 7.

Has the time not come when the policy of admitting students with conditions should be abandoned? That many of the students who fail during their first year are among those admitted with conditions is hardly open to question. If all students admitted with conditions had been excluded would not the per cent of eliminations have been substantially reduced? What motives lie back of the policy of admitting students who according to the standards set are unprepared I do not know. But it seems appropriate to recall the old adage: "You can't eat your cake and have it too." The desire to secure the maximum enrolment is incompatible with the ambition to secure the highest quality. I do not consider myself qualified to discuss this proposal in detail. I merely call attention to it in the hope that others will discuss it. It appears to me of great importance.

**Solid Geometry and Plane Trigonometry.**—Of 111 institutions reporting, 67, or 60 per cent, require solid geometry for admission to their engineering courses, while only 15, or 13½ per cent require trigonometry. This suggests my second question: Would not trigonometry be a better entrance requirement than solid geometry? If the question is considered merely from the point of view of success in later courses in mathematics, I do not hesitate to answer the question in the affirmative. The preponderance of solid geometry is perhaps due to its alleged importance in other subjects of the engineering curriculum (graphics, descriptive geometry). But even there I wonder if its value is not exaggerated. Space perception—the ability to visualize figures in space—is doubtless of great value and our high school courses in solid geometry help in this direction. But as currently taught the emphasis is largely on demonstration; the training in space perception is incidental and should come much earlier in the curriculum, preferably in the junior high school years.

Whatever may be the value of solid geometry as preparation for other engineering courses, I think there can be little doubt of its relative worthlessness as preparation for college work in mathematics compared to the value of trigonometry. At Dartmouth College we do not require solid geometry for admission nor do we teach it in the college. We have never felt the need of it anywhere in our mathematical courses. The space figures which need consideration in the calculus seem to offer no special difficulty, and instruction in solid analytic geometry proceeds smoothly without previous preparation in solid pure geometry.

Trigonometry on the other hand is a tool universally required in later mathematics courses. We therefore find it necessary to separate our freshmen into two groups according to whether or not they presented trigonometry for admission. The significant fact

that emerges from our experience is that those who come to us with trigonometry are a highly selected group. This is doubtless not due so much to the trigonometry they have learned as to the fact that they were the type who elected it. The election of trigonometry is a selective process of a high order. And it is precisely such a selective process that engineering schools should be seeking if they wish to insure better endowed students.

I would then urge that *all* institutions require more than elementary algebra and plane geometry as requirements for admission to their engineering courses, and that plane trigonometry is more desirable for this purpose than is solid geometry.

In this connection attention may be called to a project of some years standing, but which has as yet made little progress, viz. that of replacing the present one year course in plane geometry by a year course in plane and solid geometry combined. I do not propose to discuss the pros and cons of this project. A committee of the Mathematical Association of America and the National Council of Teachers of Mathematics has recently made a report on this project. Professor Dunham Jackson of the University of Minnesota, was chairman of this committee. I mention it here merely as perhaps of interest in connection with the suggestion I have just made. Possibly a year course in plane and solid geometry, properly organized, plus a half year of plane trigonometry would form the best solution of the problem raised.

**Other Selective Processes.**—Many state universities and other publicly supported institutions are legally unable to limit their enrolment. This is not true, however, of privately endowed institutions. To them is open a further means of reducing the number of eliminations if they care to adopt it. They may limit arbitrarily the enrolment in their entering classes and thereby greatly improve their quality. I am in a position to give a bit of testimony on this point which may be of interest. Dartmouth College has, for a number of years, been limiting its freshman class to about 650. The number of applicants meeting the formal entrance requirements is in each year nearly three times the number admitted. Our problem is to select the best 650 out of about 1800 applicants. This is not the place to describe in detail the methods we use to make this selection. But you may be interested in the results. The percentage of failures in freshman mathematics has dropped from an average of about 20 per cent before our selective process went into effect to about 7 per cent; and this in the face of the fact that our freshman courses in mathematics have been made considerably more difficult. The selective process has at least done one thing for us: It has practically eliminated what we used to call the "impossible" student—the student of whom we

knew two weeks after the opening of college that he would surely fail. Our system is by no means perfect—if it were, if we really succeeded in picking the best third of all the applicants we ought to have practically no failures. But it has enormously reduced the eliminations due to poor scholarship. The same way is open to other institutions which are anxious above other considerations to improve the quality of their student body. Nor would the adoption of such a policy necessarily mean any permanent reduction in size. The added prestige that would accrue to such an institution would in many cases after a few years restore the original enrolment. I make the suggestion for what it may be worth.

The question of the relative merits of entrance examinations vs. certification, the possible usefulness of psychological tests, etc., I pass over at this point. I shall have something to say about examinations and tests a little later in another connection.

### The Quality of Instruction in Secondary Schools

The quality of instruction in mathematics in our secondary schools is in general low. There are many reasons for this. The ablest men in our colleges are not in general attracted by secondary school teaching as a career. There are, of course, notable exceptions. It remains true nevertheless that the general average of ability among the men going into secondary school teaching is at best mediocre. The situation as regards our women graduates in this respect is doubtless better; but the difficulty with our women teachers is that they don't stick; they get married and leave the profession. The turn-over among secondary school teachers is enormous. It takes experience to make a good teacher and the number of experienced teachers is relatively very small.

It will not do, however, to blame the teachers. During the time I served on the National Committee on Mathematical Requirements I came in contact with very many of them. They are as a class thoroughly devoted, conscientious, hard working folk, who are doing the best they can under adverse conditions. It is the system that is to blame. There will be no radical improvement until the profession of secondary school teaching is made more attractive: by greater financial rewards, shorter hours, greater freedom, a higher social standing in the community. This is a large problem of general social organization and adjustment to the solution of which we can contribute only by using our influence individually and collectively to further what must at best be a long time evolution.

Certain specific phases of this problem we can, however, approach with the hope of securing results within a reasonable time.

I fancy we will all agree that the principal faults of our secondary school teaching of mathematics are as follows:

It is too formal; there is too much emphasis on the developments of specific skills at the expense of understanding and insight; students do not learn to think for themselves, they do not develop any real power of analysis, they find themselves helpless when confronted by a problem slightly off the beaten track; and even within the field of formal technique, within the field of the specific skills referred to, they are often inaccurate and untrustworthy, and their training seems to lack thoroughness and depth, and does not develop the mental habits which make for power and independence of thought.

If this is a fair description of our indictment, one conclusion would appear to be obvious. A teacher will be unable to give the desired type of training unless he or she has the understanding, the insight, the ability to *think* in mathematical terms, the power of analysis, desired in the pupil; and such a teacher will rarely, if ever, have the desired attributes unless he or she has had special training in mathematics. This sounds like a truism; it is a truism. But many of our school administrators act on a directly opposite principle. They appear to believe that anyone can teach mathematics by keeping a few pages ahead of the class in the textbook in algebra or geometry. At any rate it happens often, especially in our smaller schools, that a teacher whose special training has been in history, or French, or English, is given a class in algebra or geometry; a teacher who often has had no college work in mathematics at all or has had only one such course in his or her freshman year.

This practice should be stopped. It is thoroughly vicious and is to a considerable extent responsible for the formalism and mechanical character of much of our instruction. The fact is, I believe, that no subject in the secondary school curriculum is so difficult to teach *well* as is mathematics, and therefore no subject requires in so high a degree special qualifications and special training on the part of the teacher. Only men and women having such special training should be allowed to teach mathematics. Fortunately here is a situation in which we can be of some help. The practice to which I refer is most prevalent in our small high schools. Those of us who live in small communities can use our influence with the administrative authorities of our schools; we can perhaps reach other small communities through friends; our collective pressure can perhaps be brought to bear on our state departments of education. Whatever the means employed, here is a situation which needs remedying; and I know of no specific item of possible action which is more important. There is just one serious obstacle

in the way. I have recently seen a statement to the effect that, while in other subjects the supply of teachers exceeds the demand, the supply of teachers specially trained in mathematics is inadequate to meet the demand. We may hope that this state of affairs is only temporary.

The overemphasis of technique at the expense of understanding is a fault in the objectives of teaching. Such objectives are to some extent reflected in examinations and tests of various kinds.

The College Entrance Examination Board exerts an enormous influence on secondary education throughout the country. This will come as a surprise to many college teachers; it came as a surprise to me some years ago. While the C. E. E. B. functions directly for the most part in the college entrance machinery of only a comparatively few eastern institutions, its influence pervades the whole country. High schools in Kansas, in Nebraska, right here in Minnesota, even though very few of their graduates ever take the Board examinations feel that they must satisfy the Board requirements. We of the National Committee some ten years ago did our best to break down this domination, not from any hostility to the C. E. E. B., of course, but because we felt that such domination was an obstacle to the reforms we were advocating. The recommendations of the National Committee could have little practical effect if they conflicted with the requirements of this Board. (Fortunately, we solved the difficulty at that time by bringing the C. E. E. B. to adopt our recommendations.) This bit of history may be of some importance to our present discussion. In so far as desired changes in instruction can be reflected in examinations, it suggests an effective avenue of approach to exert pressure on the secondary schools of the entire country. Unfortunately, for our purpose the prevailing type of examination has hitherto failed adequately and fairly to test the qualities of insight, understanding, power as distinguished from skill or technique.

The problem would appear to be easier in geometry than in algebra. We may perhaps look forward to the time when all the questions on a geometry paper will be originals. This does not mean that the examinations will have to be unduly difficult; for it is a simple matter to devise easy as well as more difficult originals in geometry. But a boy or girl who can solve geometric originals of reasonable difficulty and variety would appear to have the geometric training we desire.

Not so with algebra; originals in algebra are tricky, and under present conditions an examination in algebra consisting predominantly of original verbal problems would be unfair. My own feeling is that the College Board has gone about as far in this direction as is wise at the present time. My point, however, is

this: It seems important that we scrutinizes the Board examination critically year after year, with a view of seeking all possible improvements. I can testify that, while the Board is, and I believe ought to be, a conservative body, it is seriously and conscientiously attempting to do its share in maintaining the best standards of secondary instruction; and that it is open to conviction when any promising change is proposed. And, as I said before, action by this Board has a direct, immediate and powerful influence on secondary school teaching. If only some one would invent a new type of examination in mathematics, which, while fair to all concerned, would require the kind of teaching we want! The path of the reformer would thereby be made much easier.

And this brings us to a closely related topic of considerable importance. The development in recent years of various types of objective, standardized tests, and its relation to our problem demands consideration. I am not referring to the so-called psychological or intelligence tests. I have reference to tests relating to specific subjects such as mathematics: the so-called prognostic tests, diagnostic tests, inventory tests, and achievement tests. This testing movement is running strong. I am not one of those who would deny that it has potentialities for good; but I am one of those who believes its prevailing tendencies to be fraught with danger. The tests most successfully developed and most extensively used place the emphasis on specific skills, technique, information; this type of test is relatively easy to formulate and to standardize. Tests for the ability to reason and to analyze, tests for imagination, inventiveness, and resourcefulness are rare, are more difficult to construct, are less successful in practice, are therefore little used.

The danger lies in the fact that the former type of test, the type which emphasizes technique and information, is being increasingly prescribed and is used not merely to test the pupils but to test the success of the teacher. There is, therefore, an inevitable tendency on the part of the teacher to direct his or her instruction by these tests. Now the good teacher will realize that the best way to train his or her pupils to meet these tests successfully is to insist on understanding and insight as well as to provide adequate practice in technique. I am convinced that many of the failures in the type of test we are considering is due to a lack of understanding on the part of the pupil of fundamental principles; and the good secondary school teacher will agree to this diagnosis.

But good teachers of mathematics are relatively scarce in our secondary schools, and they are human in that they are inclined to follow the line of least resistance. To them the cure for a lack of facility or accuracy in technique is more practice in technique and

this often involves a mere mechanical drill on the weak spots discovered by the test with no gain in understanding on the part of the pupil. There is danger in this situation. I have no remedy to offer other than watchfulness for such opportunities as may present themselves for counteracting it. The further development and successful use of the other type of tests—those emphasizing reason, constructive imagination, resourcefulness, and the power of analysis—would perhaps be the best antidote.

Another avenue of approach to the possible improvement of teaching lies through the textbooks. The exceptional teacher will rise superior to the textbook; he can achieve good results even with a poor text. But the great majority of teachers teach the textbooks; and for this reason the text used is of importance.

I wonder if the time has not come when a critical evaluation of textbooks by an impartial tribunal is possible. The idea is full of difficulties and of dangers; I think I realize them fully. Nevertheless, when we have a Consumer's Research Organization to pass on the merits of many varieties of manufactured articles, when the American Medical Association has decided to pass on the quality of food products, shall we say that the objective, impartial, unbiased evaluation of textbooks is quite out of the question? If the plan is at all feasible, it has potentialities for great good. It could, at least, help to eliminate the thoroughly bad text, and I fear there are such in use.

The purpose of such a scheme would not, of course, be to find the best text in a given subject; that would be wholly impossible. The most it could hope to do would be to classify them into two or three classes "Recommended" and "Not Recommended"; or "good," "bad," and "doubtful." Or perhaps it should not even attempt that much. Perhaps it should merely give a critical analysis of each book, the analysis to cover the selection and arrangement of material, the accuracy of the text, the clearness or otherwise of the exposition, the adequacy of the problem and drill material. A tribunal which in the course of time commanded respect by virtue of the authority of its membership and its fairness, and which made available to those concerned such critical analysis of the various texts on the market, could, it seems to me, be of great benefit.

There are, of course, many difficulties. The personnel of such a tribunal would be difficult to find. Many of those best qualified to serve would be found to have connections as authors or editors, with specific books and publishing houses which would bar them. Even if the right sort of men were found, they might be unwilling to serve. It would be a thankless job, I fear. The scheme would involve some expense. The members of what I have called the

tribunal should be paid for the time spent on such work; for if properly done it would be very time-consuming. The publication of their findings could perhaps be made through some journal, such as *The Mathematics Teacher*. If not, there would be some expense for publication and distribution. This is not the place to suggest details of organization. But I feel that the suggestion is worth careful consideration; such an organization as the Society for the Promotion of Engineering Education might appropriately undertake the project.

# THE PLACE OF UNIT OPERATIONS IN A CHEMICAL ENGINEERING CURRICULUM *

By WARREN K. LEWIS

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Fifteen years ago Dr. A. D. Little outlined the arguments in favor of presenting chemical engineering to the student in the classroom as a series of unit operations, rather than as a group of industries, so convincingly as to win for this policy substantially universal approval. In view of this fact, it would probably be a waste of time to discuss this phase of the subject. However, agreement is by no means unanimous as to where instruction in the unit operations should be introduced into the chemical engineering curriculum and how it should be presented. These matters are of such vital importance in the teaching of chemical engineering that they abundantly justify discussion. However, sound conclusions on these points can be based only upon a correct appreciation of the fundamental purposes of engineering education as a whole.

The following discussion will be based upon the premise that the primary function of education for engineering as a profession is not to familiarize the student with the methods and technique of modern industry, however important a fundamental understanding and appreciation of them may be, but that the primary purpose of the educational process is the development in the student of the initiative and the power for constructive and independent professional achievement. Knowledge of present art, appreciation of fundamental principles and the broadest possible background of information are essential to the right sort of training, but they represent the foundation only. The superstructure, without which the foundation, however sound, is professionally worthless, is the power effectively to use these resources of knowledge and experience in the solution of present difficulties. The chemical engineering curriculum must both give to the student the necessary background of information and develop in him the power to use it. In the organization of a curriculum in chemical engineering, what ought to be the function of the instruction in unit operations in the achievement of the ultimate purpose and how can that function best be attained?

* A lecture delivered before the Chemical Engineering Session of the Summer School for Engineering Teachers, University of Michigan, June 24, 1931.

As a matter of fact, the instruction in unit operations has been used at various times for three major purposes. Some teachers have used it largely as an opportunity for grounding the student in the fundamentals of science. Others have used it mainly to familiarize the student with the practices and methods of industry. Still others have looked upon it as primarily a means and opportunity for developing the initiative and power of the student. Which of these purposes ought it to serve and how can that purpose best be achieved?

The instruction in unit operations ought not to be used as a means of grounding the student in the fundamentals of science. There are teachers of engineering who believe that science can best be taught to engineering students by means of its applications. That belief is heresy, primarily because this method narrows the intellectual horizon and stunts the imagination of the student. Where science is taught by means of its engineering applications, the student may indeed learn to understand the mechanisms and processes explained to him, but he fails to visualize those processes as specific illustrations of broader principles and general laws. His scientific imagination does not develop and he is doomed to be a follower and not a leader. Too many of our engineering curricula are built upon this principle. It is perhaps to this that one must ascribe the fact that fundamental leadership in the application of science to industry has come from men of scientific rather than engineering training. Langmuir, Coolidge, Pupin, Wright, Haber, Bergius, Baekeland, Herty,—none of these is a man of engineering training. The preëminence of men of scientific training in the roster of those whose contributions to industry have been most fundamental and far reaching seems to indicate that it is best for the student to get his science from the scientific point of view, at the foot of the teacher of science himself. This will tend to deepen his scientific insight and broaden his intellectual horizon. In the chemical engineering curriculum, the mathematics, physics and chemistry should be given in the science departments, before the instruction in unit operations begins and as the essential preparation therefor. It is true that the right sort of teaching in the engineering subjects will deepen the student's appreciation of scientific fundamentals, but this result, however important, ought to be a by-product rather than the main purpose of the engineering work.

The unit operations of chemical engineering represent the tools of the profession. They are to the engineer the means available for the achievement of necessary ends. The successful engineer must be thoroughly familiar with their potentialities and limitations, with the ways in which they have been used in the past, the directions in which they have developed in the history of chemical

industry and the present status of the art of using them. In a certain sense, all of this represents merely information as to the facts. This information must be presented to the student by the instructor in the most effective way, and to this degree the instruction must be informational in character. Because this is the easy method of approach, the instructor is sometimes tempted to place this side of the subject first. On the other hand, however important this informational background may be, it ought to serve only as the stepping stone to the most essential phase of the instruction, the development of the student's initiative and power.

Before this audience one need not discuss the merits of education by doing. This principle lies at the basis of the emphasis placed on laboratory work. None the less, in the undergraduate curriculum, the function of the laboratory is inevitably largely informational and as such it is competitive with lecture, classroom and outside study. When, on the other hand, one comes to the problem of the development of initiative and power, education by doing has no competitor. It is the only effective method. However, the use of the laboratory for this purpose, essential though it is, is seriously handicapped by excessive requirement of time. It is imperative to educate by doing through a method less wasteful of time, and, for this purpose, the teacher of engineering turns to the problem method of instruction.

The use of the problem in instruction in science and engineering is almost as old as the professions themselves. In view of this fact, it is surprising how few teachers thoroughly appreciate the potentialities and value of the method. A brief discussion of the character of problem work will not be out of place.

It will perhaps be best to use in illustration the teaching of geometry, with which all are familiar. The instruction always begins with a series of theorems, which, while they make a certain demand upon the intelligence, are primarily a matter of memory. The theorem represents the method employed by the teacher of geometry to give to the student the necessary background of information. As soon as such a background has been created, the student is given problems, usually numerical, to test his grasp of the subject. However, in the early stages of instruction, these problems usually demand of the student nothing more than a memory of the subject matter already presented, together with a certain degree of intelligence in recognizing its applicability to the case in hand. Thus, the student will be asked to find the hypothenuse of a right triangle when the sides are known, or required to disentangle some correspondingly simple combination of elements. However, as soon as practicable the instructor in geometry faces the student with the so-called "original," *e.g.*, a theorem, the

statement of which is given, but not the proof. This makes it possible to find out whether the student has grasped the method of geometry and is able to apply it for himself in a case in which he does not know the details. Properly employed, the use of the original makes it possible to test and to develop all the capacity for geometrical initiative which even the brightest student may possess. The best teachers of geometry achieve their results by the effective use of originals in their instructional technique.

It is clear that, in the teaching of any quantitative science, problems, numerical or otherwise, may be employed which range in character all the way from the simple illustration of an already familiar principle to the most complicated test of a student's grasp of the fundamental methods of the science. It will be convenient to designate the two types of problems by the adjectives "illustrative" and "original" respectively. It will be clear that there is no sharp line of demarcation between the two types, but that, as the problem increases in complexity and in demand upon the intelligence and perspective of the student, it is transformed progressively from the illustrative problem to the original type. The original problem offers the most effective means known for the development of the intelligence of the student in initiative and power.

Too many teachers of science fail to appreciate clearly the distinction between the illustrative and the original types of problem. The student of chemical engineering is too likely to find the problem given him in his courses in mechanics, thermodynamics and chemistry almost exclusively illustrative in type. All he need do is look up the proper formula or combination of formulas, insert the numerical figures given him,—and the rest is merely a question of slide rule manipulation. The problems are not designed to be original in type and thus to serve both as a test of and as a means of developing the student's power of initiative.

Credit for the appreciation of these facts and for the initiative in the introduction of the original type of problem into chemical instruction belongs to Dr. A. A. Noyes of the California Institute of Technology. Over thirty years ago he started to use the original problem in instruction in physical chemistry. The success of the method has resulted in widespread adoption in the teaching of that subject. None the less, the lack of interest of science teachers in the technique of education is well illustrated by the fact that the method of Dr. Noyes has not been subjected to critical analysis nor developed to the extent that its importance justifies.

Dr. Noyes considers the use of the illustrative problem unwise, because all its advantages are inherent in the original type. It is a disgrace to give a problem which the instructor has any reason

to believe that the student knows how to do. The good problem is one which the student does not know how to do, but which, in the light of his background of knowledge and experience, the student ought to be able to solve by the exercise of a reasonable degree of intellectual ingenuity. The good problem must be neither so easy as to fail to tax the mental capacity of the student, nor so hard as to discourage his effort. It follows that the degree of difficulty of the problem should increase progressively as the power of the student develops. The introduction of this sort of problem instruction is the most important advance in the last half century in the technique of teaching applied science.

Over twenty years ago the department of chemical engineering at the Massachusetts Institute of Technology adopted this principle of teaching from Dr. Noyes and has applied the method consistently in the instruction in unit operations. The presentation cannot be given by this method alone. The problem must be preceded by an adequate formulation of the principles underlying the operation in question and the general methods of applying those principles in chemical industry. However, once this is done, the problem can be introduced and from that point on it can be used almost exclusively, not only to give scope to the initiative of the student, but also to broaden his information and develop his perspective.

In the development of problems one of the riddles the teacher must endeavor to answer is the question of suitable length. It is clear that at the start the problem should be short, but that ultimately the student should be made to face complicated situations, such as those which are ordinarily encountered in problems of commercial design. The difficult question is how rapidly to advance from the one type to the other. The short problem fails to develop perspective and power of association. The long problem tends to confuse the student with a maze of details, interfering with his grasp of individual points. The successful instructor will adjust the rate of increase in length and complexity of the problem to the rate of progress of the class and, indeed, ultimately to the capacity of the individual student.

In the engineering field it is imperative that a goodly percentage of the problems make a demand upon the judgment of the student, since otherwise the instruction has failed in one of its essential purposes. The formulation of this type of problem is difficult and correction even more so, but the educational value is great enough to justify the effort.

Dr. Noyes has been extraordinarily successful in the development of the quantitative problem of the original type in the field of physical chemistry, but he has not made great headway in the development of the qualitative problem. In physical chemistry

this is not serious, because it is essentially a quantitative science, but in predominantly qualitative subjects, such, for example, as organic chemistry, the development of the problem method of instruction has been handicapped by the difficulty of formulating suitable original problems qualitative in character. One of the most promising possibilities of advance in the technique of engineering education lies in the adequate development of the qualitative problem, original in type, as a method of instruction.

The most serious obstacle to the effective use of the original problem in engineering instruction lies in the fact that it is very hard on the instructor. The educational value of a problem is inversely proportional to the $n$th power of the number of times it has been used. Furthermore, $n$ is a large positive quantity. The solution of the old problem is too likely to be available in the fraternity files. Even aside from that fact, it is surprising how quickly re-use destroys the psychological appeal and the interest the problem arouses in the student. Meanwhile, the development of educationally suitable problems is a difficult task, demanding far more time from the instructor than its solution does from the student. Finally, the proper correction of the original problem is hard work. The most important thing to discover is the student's method of attack and the variety of solutions that a group of students can concoct is to be matched only by the indirectness of many of them. This difficulty is greatly increased in the case of problems demanding judgment on the part of the student, since both method and numerical answer may vary in solutions equally satisfactory. On the other hand, the instructor who is unwilling to spend the time and nervous energy needed to uncover the workings of the student mind, as the first step essential in any successful effort to help the student develop his mental powers, is unfit to teach.

In the field of chemical engineering, the instruction in unit operations offers unique opportunity for the effective use of the problem method of teaching. The student already possesses a reservoir of information in mathematics, physics and chemistry, upon which the engineering instructor may draw freely. The student brings to the classroom all the professional interest he is capable of developing. The problems can start on a level of difficulty that will not discourage the student, and yet deal with subject matter sufficiently new to arouse keen interest. Indeed, so wide is the variety of topics in the field of chemical engineering, that interest due to freshness of subject matter can, to a large degree, be maintained throughout the work. The problems can develop in complexity and difficulty at a rate avoiding undue discouragement and yet sufficiently rapid to give to both student

and instructor the inspiration of progress achieved. They can be so designed as to call into play every technical faculty and capacity the student may possess. The work can finally develop into relatively complicated problems of design, the solution of which will give to the student a justifiable confidence in his ability to attack the problems of chemical industry and use successfully the tools of his profession in solving them. In no other branch of instruction in the chemical engineering curriculum can one accomplish more in the development of the professional power of the student. It is because of these facts that the instruction in the unit operations continues to constitute the capstone of the curriculum in chemical engineering.

## EMPLOYMENT SERVICE

In order that the Society may be of further assistance to you, we are compiling a list of vacancies which will be open in the engineering schools of the United States and Canada next year.

If you desire to make a change in your position, please advise us the type of position desired; the section of the country in which you prefer to live; the salary expected. We should also have full information concerning your qualifications so that we may refer these to the institution seeking a man of your ability.

All information received in response to this notice will be kept confidential and sent only to institutions where there is an opening which will benefit you.

This information should be in our hands at once as appointments for next year will be made within the next few months.

If you have vacancies in your department, please list them with us.

There is no fee attached to the above service.

F. L. BISHOP,
*Secretary.*

The Secretary wrote to every engineering school in the United States and Canada asking them to list with the Society any vacancies in their staffs. The following vacancies are listed:

Instructor or assistant professor in civil engineering;
Dean of engineering;
2 professors of elementary mathematics—must be able to talk French fluently;
Head of civil engineering department;
Instructor in mechanical engineering;
Assistant professor of chemical engineering.

Many interesting comments were received; among them the following:

"The prospects of vacancies for the session of 1932–33 are very, very remote. During the present depression a man would be almost a lunatic to resign his teaching position and at present we have no lunatics on the Engineering Faculty."

"I think the employment service of the S. P. E. E. is well worthwhile and should be of decided benefit to the institutional members."

"A well invested $5.00—my dues in the S. P. E. E."

# PRACTICAL ENGLISH COURSE FOR SENIOR ENGINEERS

By

JAMES W. GRAHAM, Professor of English

AND

WM. H. BARTON, JR., Professor of Civil Engineering, Pennsylvania Military College

The criticism that many competent practicing engineers cannot make a logical and convincing report or statement on subjects with which they are thoroughly familiar is no new thing. Frequently it originates among engineers who feel themselves handicapped by inability to say what they know in the way which they feel that the importance of the matter warrants. It is argued that their lack of participation in public affairs in which they might otherwise be best fitted to take positions of leadership often results directly from this inability. It is maintained further that in many cases it is not the best but merely the most articulate engineers whose professional efforts meet with the greatest measure of success, and that ability is too often kept in the background or stifled by lack of words.

In looking for means to correct such a situation among undergraduate students, the engineering teacher naturally looks to the English department for aid. In all engineering schools a certain amount of work in English composition, and sometimes a few courses in literature are required. Several factors, however, tend to minimize the value of this instruction. Too often there is a definite antagonism on the part of the students directed toward anything which is not strictly professional. Sometimes this attitude is even encouraged by the engineering faculty. Work in English is looked upon as a nuisance, probably, but not certainly, necessary. On the other hand, the English department is likely to feel that the instruction of engineering students, whose interests are purely technical, is a burden best dealt with by being relegated to the youngest instructors, who in turn look upon it as an irksome and thankless task. These engineers have no interest in English. Why bother with them? Thus a vicious circle of indifference and antagonism is created. Another difficulty arises from the fact that work in English is rarely given beyond the sophomore year. Furthermore, it practically never has any but the vaguest reference to the stu-

dent's need for training in technical expression—assuming that a freshman engineering student is in a position to be benefited by what we so cheerfully call "Engineering English." All in all, there is usually a definite lack of coöperation, and at best the student is merely "taking English."

At the Pennsylvania Military College there exists a scheme to alleviate these difficulties which has certain characteristics which may possibly prove generally useful. In the first two years, engineering students do rather more work in standard English courses than is usual in most colleges. In addition to the usual freshman composition course, two semester hours of literature during the freshman year and four semester hours throughout the sophomore year are required. So far, all of the work is distinctly non-technical. An attempt is made to impress upon the student the fact that there is no particular reason why engineers should be less literate than members of other professions. For such a schedule, it is absolutely necessary, of course, that sympathy and unanimity of purpose exist between the engineering and the English faculties, a condition which some colleges might find difficulty in maintaining. But the distinctive feature of the plan is the work in the senior year.

Since it has been observed that courses in technical English too often drift away from their main purpose or are conducted more of less *in vacuo,* two coöperative courses have been established for senior engineering students. During the first semester an engineering seminar is conducted. In this course each student prepares a paper describing some outstanding engineering project of recent design and presents it to an assemblage of the engineering students, who discuss its features with him. This course is also scheduled on the English roster as a regularly assigned subject. Instruction and guidance in the principles of composition involved in the preparation of the report is provided by the English department. Conferences are held in which advice in methods of research is provided and problems arising in the planning of the individual paper are discussed. The writing of the report itself is supervised. Finally, the complete report presented is criticized. During the second semester of the senior year there is a similar coöperative course. Each student is required to present for graduation an original thesis covering the design or investigation of some engineering structure or to conduct a research in the laboratory. This work is also scheduled on the English roster, and the student's contact with the English department is viewed not as a separate course but as instruction in the technique of presenting professional material.

It is readily to be seen that this scheme involves a great deal of

conference instruction. The student receives advice and assistance concerning the technical phases of his problem from the professor of engineering directing his work. At the same time, the form in which his work is presented is regulated by the professor of English under whom he is also working. Thus the important question of manner of presentation is kept constantly before him.

In this way, the student gets instruction in composition of the sort with which he will have most to do in his later professional life at precisely the time when he will benefit most from it. This method of procedure seems superior to an independent course in technical composition in the senior year for several reasons, but chiefly because it applies instruction in English composition directly to the matter at hand which the student is himself interested in presenting well, rather than burdening him with a supplementary course in what he is almost certain to regard as "writing for the sake of writing." It helps him to do effectively what he would be "muddling through" if left to himself: it is instruction of the sort that he is capable of appreciating. The establishment of such courses is only one way of accomplishing an object that may be approached from many angles, and it is probably not an entirely new way, but we feel that present need among all engineering students warrants it and that it is a distinct contribution at least to our own problems in engineering education.

## MACHINE DESIGN CLEARING HOUSE

### Combining Kinematics with Machine Design

Several members of the Clearing House have suggested that we discuss the advisability of combining the teaching of Kinematics with Machine Design. The authors of a text-book which features this plan state in the preface of their book: "It is the opinion of the authors that the subject of Kinematics need not be taught as a separate subject, and that there are actual disadvantages in attempting to treat it separately."

Some teachers with whom I have discussed this question have expressed themselves as being in favor of combining the two subjects. Others are of the opinion that Machine Design can best be taught as a separate subject and that it should be preceded or paralleled by a course in "Mechanics of Machinery" or "Machine Analysis," concerned with the analysis of the motions and forces occurring in existing or proposed types of machines.

The discussions which follow have been received.

No doubt in many cases this combination would be beneficial. There are so many good design problems that could be used to tie the theory closer to the application while it is still fresh in the students' mind. This arrangement would require considerable time in order to break the student in and allow so-called "soaking in process."

I see no reason why courses in Kinematics could not be combined with courses in Machine Design since they are so closely related. However, we do not find the time in our curriculum to cover such courses adequately after the student has completed basic courses in Mechanics. For this reason we give courses in both Kinematics and Jig Design to our sophomores.

Combining the two courses is practical and will result in a saving of time. Increased learning efficiency will be obtained because: (1) the kinematics of belting may be covered simultaneously with the design of belting, and (2) the kinematics of gearing covered just previous to the design of gearing will make the design easier to comprehend. However, including work on motions of linkages, etc., in a conventional machine design book, where there is practically no application for it, is a strain on the student's sense of reasonableness.

Allow me to alternate suggestion: That cams and the kinematics of belting and gearing be definitely placed in the typical machine design course. This course, which emphasizes static design and machine elements, should be followed by one which treats of the dynamics of machinery, wherein the presentation of the graphical kinematics, including acceleration problems, is followed by actual examples of design and the elaboration of stress considerations under repeated loads.

There is no text suitable for the second course suggested, but if the sentiment were favorable enough, one probably would soon appear.

In discussing the proposition of combining the courses of kinematics and machine design we must remember that the solution of practical problems in which these subjects enter always involves their joint consideration. A mechanism or machine cannot be proportioned without consideration of the kinematical limitations and a kinematical system can not be assumed as usable without consideration of the machine design limitations.

When teaching kinematics, the mechanism is given and its kinematical relationships are analyzed and studied. This is perhaps, as yet, the only way to proceed, but it must be recognized that after graduation the student is faced with the reversed process. That is, when developing machinery general kinematical relationships are known or assumed and the mechanism to effect them must be selected, or invented and studied. As every practicing engineer knows, this is more or less of a trial and error process. As a result modifications are often required in either one or both phases to produce a machine or mechanism which will fulfill the kinematical and machine design requirements. This at once shows the inseparable relations between the two subjects and also the need for a fundamental knowledge of the characteristics of the standard kinematical system.

Sooner or later the student will be taught, or will discover, that the geometrical and mathematical limits of a kinematical system are further narrowed by machine design consideration. If he can learn this in school by studying both subjects simultaneously and performing exercises in which such limitations are met, it will make him more valuable after graduation.

Combining these subjects in one course would probably reduce the total time required to produce the same result in the student, for it would enhance his interest due to the realization of possible practical use, and would provide a means of visualizing or reducing to concrete form, something which otherwise is more or less intangible.

Considering the advantages, it appears advisable to work toward

a combination of kinematics and machine design in institutions teaching these as complementary courses.

From the first course in drawing through descriptive geometry, kinematics, strength of material, mechanics and machine design the intention is to equip the student with sufficient knowledge and training so that he may fit into the engineering design work of the large corporation or the more immediate requirements of the small company which is more likely to expect practical results from the college graduate. Past custom dictates that their knowledge should be imparted in small packages carefully labeled and of certain value as measured by credit hours. Probably all of the above subjects could be taught with profit under the single head of machine design if the machine design staff could include as much authority in each phase of the subject as is now available in the different departments now handling the work. Surely descriptive geometry would be less academic and more practical if lost in a good drawing course that could teach the determination of clearances and interferences as well as simple detailing. Doubtless the same would be true of relating kinematics to machine design rather than to three or four credit hours. Why should the kinematic and strength relations of gear teeth not be taught as related subjects? Such a change would be an upset to present methods of teaching and the majority of available texts but the practical difficulties we see may be more imaginary than real. A few experiments would be helpful to all of us.

While it is possible to give a combined course of Kinematics and Machine Design, to my mind it would hardly be satisfactory. In case of such a combined course, it would be possible to touch only the high points of Kinematics.

I am using a text on Machine Design which has considerable material in the introductory portion of the book treating of both Kinematics and Mechanics of Materials. This material is very good for reference and does touch on the most important parts of both subjects but could hardly be substituted for courses in either subject.

I cannot imagine anyone would consider seriously combining Machine Design with Strength of Materials, and I can not see that it would be any more satisfactory to combine Machine Design with Kinematics.

Kinematics is a fundamental subject and certainly covers enough to justify a separate course and if given combined with something else either one or the other will suffer.

At this University we are teaching the subjects of Kinematics and Machine Design in one continuous course known as Machine

Design, but we do not take up the calculation of stresses in machine members until we have completed the study of mechanical movements, velocities and accelerations. One reason for this is the absence of a satisfactory text book that combines the two subjects in their proper proportions giving adequate, but not undue attention to each. Another reason is that motions, velocities, accelerations, and static forces in mechanisms can best be studied without considering the sections, contours or weights of the various members. A third reason is that students who have completed one semester of applied mechanics are prepared to start the subject of kinematics of machines but will not be ready for machine design proper until a further course in the strength of materials has been pursued. It is sometimes desirable that this latter course be taken at the same time as kinematics.

To the writer the logical procedure would seem to be a progression from the simple to the more complex, and hence the proper order of subjects would be:

(1) A study of mechanisms with reference to the motions produced.
(2) Graphical and analytical determination of velocities in mechanisms.
(3) Graphical and analytical determinations of accelerations.
(4) The study of inertia forces in machine parts.
(5) The graphical determination of static forces in mechanisms: (*a*) disregarding friction and (*b*) taking account of friction.
(6) The application of Mechanics to the design of machine parts.
(7) The study of inertia forces in machine parts.

Any attempt to combine two or more of the above subjects is liable to result in overemphasis of one phase of the subject at the expense of the other.

I see no disadvantages in combining the teaching of Kinematics with Machine Design. If the design problems are well chosen and sufficient time is allowed for the course, I believe the subjects can be taught equally well in combination. In fact they were so taught here for several years. Our principal trouble at that time was the lack of a suitable text, and also the time that we were allowed for the course was too short to cover both subjects well.

To teach either Kinematics or Machine Design effectively requires that they be taught separately.

A review of a recently (1929) published text-book on Machine Design which combines the subjects Kinematics and Machine Design is published in *Mechanical Engineering,* June 1930, page 643.

# COÖPERATIVE EDUCATION AND THE BUSINESS DEPRESSION

F. G. SEULBERGER

Drexel Institute

The present chaos in the business world is giving the coöperative system of education the most severe test it has had to face since its inception some twenty-five years ago. Difficulties of placement are being surmounted with varying degrees of success in the twenty-odd colleges which are conducting coöperative courses at the present time. Those institutions which can point with pride to figures representing practically 100 per cent. placement owe their success to several factors.

The degree to which the school placement official has been able really to interest the coöperating companies in the plan and the amount of good will which he has created among these outlets is proving to be the greatest single factor in the continuance of student employment in these trying times. What in many cases is proving of even greater value is a more or less intimate friendship which the coördinator has built up between himself and the various executives he contacts. One of the most important conditions which enters into the ability of the school to keep the coöperative employers happy with the system is the past performance of students and, of course, back of this, the placement officer's ability to choose the proper man for the job. Knowing definitely and selecting the exact type of student who will suit a certain executive and who also will qualify for the work is an invaluable factor in cementing solidly the school's relationship. The solidity of that relationship is most severely tested under present unfortunate conditions, and where it does not have a real foundation, it breaks down with the first general layoff the company must make in order to cut expenses.

In order to compensate for the coöperative layoffs which are bound to occur among the companies which, in normal times, bear the major portion of the load, it becomes necessary under present circumstances to perform ceaseless and well planned missionary work among those potential outlets not heretofore solicited. When new jobs are opened in this way, extra caution must be exercised in placing, as trail blazers, exceptional men, that is, students whose scholastic work is above average and who have had a successful record in previous coöperative work.

The strategic location of the school with respect to industry and other engineering endeavor is obviously of paramount importance when the school is called upon to tax a greater portion of the possible outlets, as is necessary during the present unemployment crisis. Certain schools which heretofore needed only to work with a fraction of the group of available employers are in a preferred position at present. Normally, in some cases, it was necessary for the school to contact only those companies which provided unusual opportunities in the way of practical training, or those companies which fell in with the system of their own volition. There was always available a large list of companies which, in reality, were virgin territory, consisting of smaller organizations, distant or isolated factories, and others. When business became poor, the intensive solicitation of these additional potential outlets served in a large measure to supplement the regularly coöperating firms which had been forced to lay off students. Unfortunately some colleges were not in such a favored position, with the result that they were faced with a constant and growing unemployment problem.

The present crisis has, we believe, served to proved that the longer alternating periods between school and industry have a distinct advantage over the shorter term of four or six weeks. The longer period has a greater appeal for the employer, at least in most cases, because it is almost always necessary for the student to be "broken in" and the company will be more likely to get productive value out of the student if he remains on the job a longer time after the breaking in process. Thus, the employer is given one less argument to use against the system, and anything which gives him less sales resistance enables the school to keep a greater number of jobs and acquire new ones. If the school is on a three-months basis and can double this term when the company so desires, the student can be left on the job for a half-year, an arrangement which is attractive to the employer because it cuts down his labor turnover. A corollary disadvantage of the shorter term is the fact that each replacement of students provides an opportunity for the employer to cut expenses by discontinuing the position.

# The T-SQUARE PAGE

DEVOTED TO THE INTERESTS OF THE DIVISION OF ENGINEERING DRAWING

FREDERIC G. HIGBEE, EDITOR

*Visualization.* The "cube test" devised by Dr. C. V. Mann to measure to what extent, if any, the study of Engineering Drawing and of descriptive geometry develops the power to visualize has been given to students at the Missouri School of Mines, and at the University of Iowa both *before* and *after* studying these subjects. Dr. Mann reports: ". . . the power to visualize has been greatly developed in the students as a whole," ". . . our drawing placement examination and the visualizing test have made a very reliable selection of students with general scholarship as a criterion. I think we have come close to doing what engineering teachers have wanted to do for the past twenty years. We have selected (on the basis of these tests) the group that will be on the platform on graduation day. . . ." The results from the Iowa tests have not yet been completed, but a high correlation is evident between high ranking men in other tests and in first semester scholarship and high ranking men in the cube test.

A new test of the power to visualize which shows great promise has been developed by W. J. McCauley of Tucson, Arizona. A block—1" × 1½" × 2" for example—is so cut that six tetrahedrons are formed. The face of the tetrahedron coincident with the surface of the original is in each case a right triangle. The test consists of giving each student a set of these six tetrahedrons properly numbered and 144 drawings (each of the blocks can have 24 positions) of the possible position these could occupy with respect to the planes of projection, oblique positions not being considered. The student is required to identify the tetrahedron which is described in each drawing. Of this new test, Dr. Mann writes: "Here is something I am sure all our teachers of descriptive geometry are going to want to know about. . . ."

*Engineering Drawing Problem.* Problem I, page 145, French. How many end views may be drawn of the block shown in plan and elevation? Professor C. H. Schuman, Jr.

*Readings.* Suggested by Rexford Newcomb, University of Illinois: Newcomb, R., "The Bridge as Architecture," Architectural Forum, Vol. XLIV, pp. 73–78, 243–248; Newcomb, R., "Outlines of the History of Architecture," Part I, John Wiley and Sons, New York, 1931; Wright, Frank Lloyd, "Modern Architecture," Princeton University Press, Princeton, 1931; Watson, W. J., "Bridge Architecture," Helburn, New York, 1927; Whitney, Charles, "Bridges, their Art, Science & Evolution," Rudge, New York, 1929; Zucker, Paul, "Die Brücke," Wasmuth, Berlin, 1921.

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BARNWELL, GEORGE W., Assistant Professor of Economics of Engineering, Stevens Institute of Technology, Hoboken, N. J. Harvey N. Davis, H. P. Hammond.

CASS, RILEY T., Instructor in Civil Engineering, University of Colorado, Boulder, Colo. H. S. Evans, C. L. Eckel.

COONRADT, ARTHUR C., Assistant Professor of Heat Power Engineering, New York University, New York City. Collins P. Bliss, F. L. Bishop.

CRUZEN, FRED T., Instructor in Drawing and Descriptive Geometry, University of Minnesota, Minneapolis, Minn. O. M. Leland, R. F. Schuck.

DOWDELL, RALPH L., Professor of Metallography, University of Minnesota, Minneapolis, Minn. O. M. Leland, R. W. French.

FIELDER, GEORGE J., Laboratory Instructor in Electrical Engineering, University of Kansas, Lawrence, Kansas. D. C. Jackson, Jr., R. W. Warner.

FAHY, FRANK E., Instructor in Civil Engineering, Antioch College, Yellow Springs, Ohio. Ben H. Petty, Tom C. Lloyd.

OEHRLI, JOHN W., Assistant Chief Engineer, Automotive Division, Lycoming Mfg. Co., Williamsport, Pa. Louis Mitchell, S. D. Sarason.

PAJOT, CLAYTON J., Instructor in Engineering, University of Detroit, Detroit, Mich. David P. Gilmore, Jasper Gerardi.

QUAID, LLOYD J., Instructor in Drawing and Descriptive Geometry, University of Minnesota, Minneapolis, Minn. W. H. Kirchner, R. F. Schuck.

RANDOLPH, EDGAR E., Professor of Chemical Engineering, North Carolina State College, Raleigh, N. C. John M. Foster, L. L. Vaughan.

SMITH, WALDO E., Assistant Professor of Civil Engineering, North Dakota Agricultural College, Fargo, N. D. R. M. Dolve, J. R. Van Ornum.

STRANE, ARCHIBALD J., Instructor and Head, Mathematics Department, Duluth Junior College, Duluth, Minn. G. H. Comstock, W. R. Appleby.

SUTHERLAND, LEWIS B., Instructor in Architectural Engineering, University of Colorado, Boulder, Colo. H. S. Evans, C. L. Eckel.

SWANSON, CARL E., Instructor in Engineering Mathematics, University of Minnesota, Minneapolis, Minn. O. M. Leland, R. W. French.

WHITENER, JOHN S., Associate Professor of Sanitary Engineering, North Carolina State College, Raleigh, N. C. John M. Foster, Wm. Hand Browne.

## MEMBERSHIP CAMPAIGN FOR 1931–32

October 5, 1931

*To the Members of the Society:*

Will you secure at least one new member for 1931–32?

Last year, through the coöperation of the members we added 235 new members to the rolls of the Society. With your assistance we can exceed that number this year. We are enclosing an application blank for your convenience and shall be glad to send you as many more as you may desire. If you need a blank before we could get it to you, ask your Dean to let you have one of his. We are sending a supply of application blanks to each Dean just for emergencies like this.

Beginning with the November JOURNAL we shall publish the list of institutions with the number of members in each and the number of applications received from each. We shall correct this each month thereafter. By this method you will be kept informed of the progress your institution is making in enrolling its staff in this Society.

The dues are $5.00 per year. There is no initiation fee and subscription to the JOURNAL OF ENGINEERING EDUCATION is included in the dues. Have the applicant fill out the blank, make out a check for dues—made payable to the S. P. E. E.—secure two sponsors, and return this to the Secretary, F. L. Bishop, University of Pittsburgh, Pittsburgh, Pa. We will then present his name to the Council for election and notify him as soon as possible. However, his subscription, if check for $5.00 accompanies the application, begins with the September number of the JOURNAL.

Trusting we may again have your coöperation, I am,

Cordially yours,

F. L. BISHOP,
*Secretary.*

120 new members added this year.

## MEMBERS IN ENGINEERING SCHOOLS AND COLLEGES

| Institution | Members Nov. 3, 1931 | Applications Received after Nov. 3, 1931 |
|---|---|---|
| Akron, Univ. of | 9 | |
| Alabama Poly. Inst. | 13 | |
| Alabama, Univ. of | 2 | |
| Alberta, Univ. of | 3 | |
| Antioch College | 2 | 1 |
| Arizona, Univ. of | 8 | |
| Arkansas, Univ. of | 11 | |
| Armour Inst. Tech. | 27 | |
| Beirut, Univ. of (Syria) | 1 | |
| Bombay C. E. College | 1 | |
| Bradley Poly. Inst. | 2 | |
| Brazil-Poly. School of State. | 1 | |
| British Columbia, Univ. of. | 4 | |
| Brooklyn Poly. Inst. | 21 | |
| Brown Univ. | 9 | |
| Bucknell Univ. | 13 | |
| Buffalo, Univ. of | 1 | |
| Butler Univ. | 1 | |
| Calif. Inst. Tech. | 8 | |
| Calif., Univ. of | 15 | |
| Calif., Univ. of So. | 6 | |
| Carnegie Inst. of Tech. | 14 | 1 |
| Case School of Applied Science | 29 | |
| Catholic Univ. | 1 | |
| Cincinnati, Univ. of | 6 | 1 |
| Clarkson College | 8 | |
| Clemson College | 10 | |
| Colby College | 1 | |
| Colorado Agri. College | 6 | |
| Colorado School of Mines | 10 | |
| Colorado, Univ. of | 19 | 2 |
| Columbia University | 28 | 1 |
| Connecticut Agri. College | 1 | |
| Cooper Union | 14 | |
| Cornell University | 28 | |
| Cornell College | 1 | |
| Dartmouth College | 4 | |
| Dayton, Univ. of | 6 | 1 |
| Delaware, Univ. of | 8 | |
| Denison Univ. | 2 | |
| Denver, Univ. of | 1 | |
| Detroit University | 14 | 1 |
| Drexel Institute | 8 | |
| Duke Univ. | 7 | |
| Duluth Jr. College | 2 | 1 |
| Ecole Polytechnique | 7 | |
| Ely Jr. College | 1 | |
| Escuela Centrale de Ing. Ind. | 1 | |
| Evansville College | 3 | |
| Fenn College | 12 | |
| Florida, Univ. of | 7 | |
| Franklin and Marshall | 1 | |
| Franklin Union | 2 | |
| Fresno Teachers College | 0 | 1 |
| General Motors Inst. | 5 | |
| George Washington Univ. | 3 | |
| Georgia Inst. of Tech. | 15 | |
| Gettysburg College | 2 | |
| Ghent, Univ. of | 1 | |
| Girard College | 1 | |
| Harvard University | 16 | |
| Haverford College | 2 | |
| Hawaii, Univ. of | 3 | |
| Howard Univ. | 3 | |
| Idaho, Univ. of | 12 | 2 |
| Illinois, Univ. of | 54 | |
| Indiana Univ. | 1 | |
| Iowa State College | 38 | |
| Iowa State University | 23 | 2 |
| James Millikan Univ. | 2 | |
| John Tarleton Agri. College. | 1 | |
| Johns Hopkins Univ. | 3 | |
| Joliet Jr. College | 1 | |
| Kansas State College | 42 | 1 |
| Kansas, Univ. of | 18 | 1 |
| Kentucky, Univ. of | 10 | |
| Lafayette College | 12 | 2 |
| Lawrence College | 1 | |
| Lehigh Univ. | 15 | |
| Leningrad Poly. Inst. | 1 | |
| Lewis Inst. | 1 | |
| La. Industrial Inst. | 1 | |
| La. Southwestern Inst. | 2 | |
| La. State Univ. | 2 | |
| Louisville, Univ. of | 16 | |
| Lwow, Poly. of | 1 | |
| Maine, Univ. of | 21 | 3 |
| Manhattan College | 7 | |
| Marine Union Jr. College | 1 | |
| Marquette Univ. | 10 | |
| Marshall College | 1 | |
| Maryland Univ. of | 1 | |
| Mass. Agri. College | 1 | |
| Mass. Inst. Tech. | 45 | 2 |
| McGill Univ. | 9 | |
| Mechanics Inst. | 2 | |
| Mercer College | 1 | |
| Mexico, Univ. of | 2 | |
| Michigan College Mines | 5 | |

| Institution | Members Nov. 3, 1931 | Applications Received after Nov. 3, 1931 |
|---|---|---|
| Michigan, Univ. of | 47 | |
| Michigan State College | 11 | |
| Minnesota, Univ. of | 70 | 6 |
| Mississippi A. & M. | 4 | |
| Missouri School Mines | 10 | |
| Missouri, Univ. of | 17 | 1 |
| Modesto Jr. College | 1 | |
| Montana School of Mines | 11 | |
| Montana State College | 3 | |
| Mt. Allison Univ. | 2 | |
| Nanking Tech. College | 1 | |
| Nebraska, Univ. of | 24 | |
| Nevada, Univ. of | 3 | |
| Newark College of Eng. | 13 | |
| New Hampshire, Univ. of | 11 | |
| New Mexico A. & M. | 3 | |
| New Mexico School Mines | 1 | |
| New Mexico, Univ. of | 3 | |
| New York, College of City | 7 | 1 |
| New York Univ. | 18 | 2 |
| North Carolina State College | 9 | 2 |
| North Carolina, Univ. of | 11 | |
| North Dakota, Agr. College | 3 | 1 |
| North Dakota, Univ. of | 4 | |
| Northeastern Univ. | 20 | 1 |
| Northwestern Univ. | 7 | |
| Notre Dame, Univ. of | 1 | |
| Norwich Univ. | 3 | |
| Nova Scotia Tech. College | 1 | |
| Ohio No. Univ. | 2 | |
| Ohio Mechanics Inst. | 2 | |
| Ohio State University | 56 | |
| Ohio University | 1 | |
| Oklahoma A. & M. | 13 | |
| Oklahoma, Univ. of | 7 | |
| Oregon State College | 16 | |
| Oregon Inst. Tech. | 1 | |
| Pasadena Jr. College | 4 | |
| Pei Yeng Univ. | 2 | |
| Penna. Military College | 2 | |
| Penna. State College | 37 | |
| Penna., Univ. of | 15 | 1 |
| Philippines, Univ. of | 1 | |
| Pittsburgh, Univ. of | 26 | |
| Porto Rico, Univ. of | 3 | |
| *Pratt Institute | 33 | 4 |
| Princeton University | 12 | |
| Purdue University | 87 | 2 |
| Rensselaer Poly. Inst. | 13 | |
| Rhode Island State College | 5 | |
| Rice Institute | 7 | |
| Rindge Tech. School | 1 | |
| Riverside Jr. College | 1 | |
| Robert College | 5 | |
| Rochester, Univ. of | 3 | |
| Rose Poly. Inst. | 9 | |
| Rutgers Univ. | 14 | |
| St. Thomas, College of | 1 | |
| Santa Clara, Univ. of | 1 | |
| Saskatchewan, Univ. of | 2 | |
| South Carolina, Univ. of | 1 | |
| South Dakota School Mines | 11 | |
| South Dakota State Coll. | 2 | |
| South Dakota, Univ. of | 3 | 1 |
| Southern Methodist Univ. | 5 | |
| Stanford University | 14 | |
| Stevens Inst. Tech. | 13 | 1 |
| St. John's Univ. | 1 | |
| Swarthmore College | 6 | |
| Syracuse Univ. | 14 | |
| Tangshan Univ. | 1 | |
| Tennessee Poly. Inst. of | 2 | |
| Texas Agri. College | 2 | |
| Texas A. & M. | 23 | |
| Texas College of Arts | 1 | |
| Texas College Mines | 1 | |
| Texas Tech. College | 14 | |
| Texas, Univ. of | 12 | |
| Toledo, Univ. of | 4 | |
| Toronto, Univ. of | 9 | |
| Trinity College | 1 | |
| Tufts College | 18 | |
| Tulane University | 9 | |
| Tulsa, Univ. of | 1 | |
| Union College | 10 | |
| U. S. Military Academy | 3 | |
| U. S. Naval Academy | 7 | |
| Utah Agri. College | 2 | |
| Utah, Univ. of | 9 | |
| Valparaiso Univ. | 1 | |
| Vanderbilt University | 5 | |
| Vermont, Univ. of | 10 | |
| Villanova College | 1 | |
| Virginia Military Inst. | 7 | |
| Virginia Poly. Inst. | 15 | |
| Virginia, Univ. of | 13 | |
| Washington State Coll. | 9 | |
| Washington Univ. (St. Louis) | 13 | 3 |
| Washington, Univ. of | 16 | |
| Wentworth Institute | 5 | |
| West Virginia Univ. | 10 | |
| Wisconsin, Univ. of | 34 | |
| Worcester Poly. Inst. | 27 | |
| Wyoming, Univ. of | 7 | |
| Yale University | 38 | |

* Faculty 100% members of S. P. E. E.

*Return to the Secretary, F. L. Bishop, University of Pittsburgh, Pittsburgh, Pa.*

**Society for the Promotion of Engineering Education**

Date.....

THE UNDERSIGNED desiring to become a member of

THE SOCIETY FOR THE PROMOTION OF ENGINEERING EDUCATION

hereby agrees to conform to the requirements of membership, if elected and submits the following:

STATEMENT OF QUALIFICATIONS

*Full Christian Name and Surname*.....
Print Last Name First Middle

*Mailing Address (Number and Street)*.....

*Post Office (City and State)*.....

*Full Title of Professional Position*.....
(Title) (Department)

*Full Name fo Institution*.....

*(To be Signed by Two Sponsors)*.....

SPONSORS { .....
.....

## CORRECTION

Through an accident the Greek letter rho in the numerator of the fraction standing immediately before the integrals in paragraph (8), p. 382, January issue of the Journal of Engineering Education, appears damaged in some of the copies. The fraction should be: $\rho c \div 4\pi L_m$.

## COLLEGE NOTES

**Columbia University.**—Plans for the expansion of the School of Engineering have been announced by Dean Joseph W. Barker. Completion of this building program would convert the Engineering School into a center rivaling in size and scope the present Columbia Medical Center. The engineering center would consist of new structures on Morningside Heights in addition to the buildings already there, and of an engineering research institute on a site not yet designated.

The first step in the program involves the construction of an underground vault in front of the present School of Engineering, to serve as laboratories for the several engineering departments. A second vault would be constructed in front of the School of Mines. Eventually, buildings similar in size to the present ones would be erected over these vaults and would provide additional class and laboratory facilities.

The research institute would contain the heavy machinery required by graduate students and research engineers, and would probably be erected on a water front site. It would be used largely by graduate students.

A Faculty Committee on Plans has been appointed, consisting of Professors Frank L. Eidmann (chairman), Eric R. Jette, Walter A. Curry, William J. Krefeld, and Lincoln T. Work. An Alumni Committee composed of Lazarus White (chairman), H. C. Carpenter, and Edmund A. Prentis, ex officio, has also been named.

**Iowa State College.**—Organized efforts are being made by the Department of Industrial Arts to increase the quality, scope, and effectiveness of graduate work. During the summer session of 1931 fifty-two students in industrial arts were doing work toward advanced degrees. This unusual interest in graduate work has created problems in the handling of research which must be dealt with in some organized manner. Previously, all of the graduate

research work was taken care of on an individual basis. Now, a new course, Problems in Research, has been organized which considers, analyzes and criticizes past research efforts in industrial arts education; sets forth problems which are yet unsolved; develops appropriate methods of procedure; and attempts to discover valid criteria which will serve as standards of attainment in industrial arts research work. During the course a student chooses a problem, makes up a bibliography, finds out what has been done previously on the problem, and sets down step by step his method of attack on his problem. After this organized course, the graduate student is assigned to a faculty member for further help and guidance. In this manner much time is saved, graduate students come to think in terms of research, and they are prepared to make a real contribution because of the foundational training.

The undergraduate curriculum in industrial arts has recently been revised so as to meet new needs. From an analysis of the work done by 700 industrial arts teachers in the state of Iowa, several changes were deemed advisable. First, the industrial arts graduate should be able to teach several kinds of shopwork. The previous curriculum was dominated by courses in woodworking and several of these have been replaced by courses in metalworking, electrical construction and general shop. Secondly, industrial arts teachers also are often required to take charge of other subjects such as athletics, agriculture, principalships and physical science. The curriculum was revised to meet these needs. Thirdly, the cost of administering the industrial arts curriculum was felt to be unreasonably high and the new curriculum has been so organized that costs will be considerably reduced. At the same time it is hoped that more efficient instruction will result from the changes which have been made.

**Massachusetts Institute of Technology.**—Many educational institutions are offering short courses free of charge as a morale-sustaining effort for the intellectually superior unemployed. Technology is doing its part. In connection with the Massachusetts Emergency Committee on Unemployment, Professor W. P. Fiske is offering instruction in Accounting. Under the same auspices Professor R. F. Elder is leading a group interested in problems in Marketing. In collaboration with members of the Harvard, Boston University, Simmons, and Tufts instructing staffs, Professor F. A. Magoun is offering work covering social adjustment in business and the professions, methods of annoying the boss, relations between subordinates and superiors.

More narrowly confined to Technology itself are Professor J. C. Balsbaugh's Distributions of Electricity for Light and Power; Professor R. G. Hudson's Electrical Equipment of Buildings; Professor

J. O. Sumner's European Civilization and Art; Professor G. Gilboy's Foundations and Soil Mechanics; Professor C. B. Breed's Highway Engineering; Professor H. W. Hayward's Materials; Professor J. Holt's Mechanical Equipment of Buildings; Professor R. M. Smith's Production Methods; and Professor D. Peabody's Reinforced Concrete Design.

Courses began on February 9 and will continue until May 25, 1932.

Dr. Robert J. Van de Graaf of the Department of Physics is constructing a generator to operate at a potential of 15,000,000 volts. This machine is designed on the same principle as the one from which Dr. Van de Graaf was successful in obtaining 1,500,000 volts, and is to be used in new attacks on the problem of atomic disintegration.

**Michigan College of Mining and Technology.**—Winter-term registrations at the Michigan College of Mining and Technology brought the total up to 614 regular students, a record number and a gain of 56 over last year's figures. In addition, 114 special students are now on the books as against 45 a year ago. Departments leading in enrollment are electrical engineering, mining engineering, and metallurgy, with 133, 121, and 92 students respectively.

Enlargement of the faculty from 50 to 64 members this past October has permitted not only additional sections of present courses but also the establishment of 16 new courses. Among these are internal combustion engines, history of architecture, blowpipe analysis, crystal measurements, crystal drawing, advanced petrology, economic geography of Asia, engineering and scientific German, beginning, intermediate, and advanced French, American government and politics, gas and fuel analysis for metallurgists, ferrous metallurgical calculations, and non-ferrous metallurgical calculations. These last two constitute an extensive treatment, for advanced students, of material formerly given more briefly in courses bearing other names.

Courses whose introduction next year has been approved by the faculty and the board of control include physical chemistry for metallurgists, special non-ferrous alloys, alloy steels and ferrous alloys, advanced analytical chemistry, operational circuit analysis, systematic crystallography, principles of finance, advanced technical German, and industrial and recreational athletics.

The last-named course, which Michigan Tech is one of the first colleges in the country to present, will teach students how to organize and direct a comprehensive athletic and play program for factories, commercial establishments, and communities as a whole.

**University of Michigan.**—As a part of Shop 7, Jig and Fixture Design, the Department of Engineering Shop has scheduled as

speakers a number of prominent Detroit engineers, who will discuss problems dealing with Tool Engineering.

Mr. William F. Wise, Vice-President and Manager of Sales of the Ex-Cell-O Aircraft and Tool Corporation, will speak on "Selling, Designing, and Fabricating Tools and Special Machines."

Mr. A. N. Goddard, President of Goddard and Goddard Company, will discuss "Milling Cutters, their Design and Fabrication."

Mr. C. J. Oxford, Chief Engineer of the National Twist Drill and Tool Company will discuss "The Design and Fabrication of Twist Drills and Reamers."

**Newark College of Engineering.**—Professor Robert B. Rice, of the Mechanical Engineering Department has developed a new method of making torque and dynamometer tests on airplane engines. This method is simple of operation and design, and hence is practical for the use of students in the laboratory. The test stand and equipment is not elaborate or expensive, but the results obtained compare favorably with results obtained using more complicated, and prohibitive procedures and equipment.

## BOOK REVIEWS

*General Mechanical Drawing for Beginners.* ROBERT C. WOELLNER AND EUGENE C. WITTICK. Ginn and Company. Price $1.12.

This is a very well written text for beginners in mechanical drawing who simply want the rudiments of the subject. The arrangement is very good and the plates and exercises are well selected and graded. This text should be suitable for courses of a non-technical nature.

L. McC.

*American Universities and Colleges.*—In addition to the exhibits supplied by the administrative officers of each of 521 accredited colleges and universities in America, giving full details regarding organization and control, property and resources, requirements for admission and for graduation, fees, number of students in attendance and degrees conferred, there are lists of professional schools of Agriculture, Architecture, Business, Dentistry, Education, Engineering, Forestry, Journalism, Law, Library Science, Medicine, Pharmacy, Veterinary Medicine, Social Work and Theology, with statements of the latest formulations of standards by the professional groups in each profession.

There is an alphabetical list of 2,602 full professors giving graduate instruction in the 29 universities which are members of the Association of American Universities, and an alphabetical list of the 3,085 administrative officers—presidents, deans, registrars, etc. —of the 521 institutions. There is an index of the institutions arranged by geographical location as well as the list arranged alphabetically according to legal title of the corporation. The statistics given are for the collegiate year 1930–31.

It has been prepared by the American Council on Education, Washington, D. C., and published with the help of a subvention from the General Education Board at four dollars by the Williams and Wilkins Company of Baltimore, Maryland.

*The A. S. H. V. E. Guide, 1932.*—The American Society of Heating and Ventilating Engineers Guide 1932 is now available. This, the 10th edition, is dressed in an entirely new binding—a neat, light blue, flexible cover. There are four major sections, namely, the Text Section, the Manufacturers' Catalog Data Sec-

tion, the Index to Modern Equipment and the Membership Roll of the Society.

The Text Section contains 40 chapters of important data on the design and installation of heating, ventilating and air conditioning systems. Approximately 50 per cent. of the subject matter is entirely new, and every chapter has been rewritten and revised. Many subjects not previously treated in The Guide, are included.

The Catalog Data Section has been carefully coördinated with the text, and contains supplementary information on specific materials, equipment and accessories available for heating and ventilating service. In the Catalog Data Section will be found sizes, shapes, capacities, dimensions, space requirements and applications so important to the engineer, architect and contractor in planning, specifying and installing materials and equipment. The two sections are so interlocked that they are practically in dispensable to each other, and for the best results it is recommended that the corresponding references in each section be consulted in all cases. The Catalog Data Section is dedicated to the presentation of reliable facts and figures concerning the products shown, eliminating as far as possible unnecessary "sales talk" and comparisons.

956 pages. Single copies $5.00. Obtainable from the American Society of Heating and Ventilating Engineers, 51 Madison Avenue, New York, N. Y.